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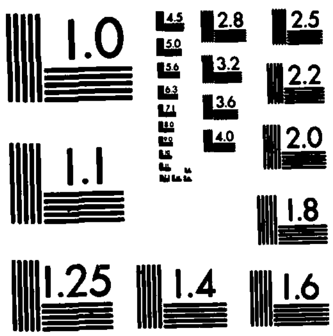
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RESEARCH AND DEVELOPMENT TECHNICAL REPORT
CORADCOM – 79 – 0789 – 8

MANUFACTURING METHODS AND TECHNOLOGY PROGRAM FOR RUGGEDIZED TACTICAL FIBER OPTIC CABLE

D. TAYLOR

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AD A124086

EIGHTH PROGRESS REPORT

FOR PERIOD

OCTOBER 1981 – MARCH 1982

APPROVED FOR PUBLIC RELEASE ; DISTRIBUTION UNLIMITED

CORADCOM
US ARMY COMMUNICATION RESEARCH & DEVELOPMENT COMMAND
FORT MONMOUTH, NEW JERSEY 07703

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This project has been accomplished as part of the U.S. Army Manufacturing Methods and Technology Program which has as its objective the timely establishment of manufacturing processes, techniques, or equipment to insure the efficient production of current or future defense programs.

ITT

Electro-Optical Products
Division

Defense-Space Group
International Telephone and
Telegraph Corporation

7635 Plantation Road
Roanoke, Virginia 24019
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January 31, 1983
NEH: 2752

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Cameron Station (Building 5)
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Attention: DTIC-TCA

Subject: Contract DAAK80-79-C-0789
SLIN0004AB, Quarterly Report # 8 (Revised)

Gentlemen:

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Sincerely,

ITT ELECTRO-OPTICAL PRODUCTS DIVISION

Nelson E. Hoag

Nelson E. Hoag
Contracts Manager

jrf

MANUFACTURING METHODS AND TECHNOLOGY PROGRAM

FOR RUGGEDIZED TACTICAL FIBER OPTIC CABLE

Eighth Progress Report

Contract DAAK80-79-C-0789

For the Period October 1981-March 1982

Object of Study:

To Establish an Automated Production
Process for Ruggedized Tactical
Fiber Optic Cable

Approved for public release; distribution unlimited.

Prepared for:

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Procurement Directorate, Procurement Division D
Fort Monmouth, New Jersey 07703

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Date: October 15, 1982
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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This report covers the period from October 1981 through March 1982 of the manufacturing methods and technology program for ruggedized tactical fiber optic cable. The scope of this effort, as reported herein, includes the following tasks and achievements:

a. Low temperature impact study

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b. Complete fabrication and evaluation of confirmatory sample cables

c. Initiate low temperature fiber study

SUMMARY

This report covers the period from October 30, 1981, to March 31, 1982, of the Manufacturing Methods and Technology (MM&T) Program for Ruggedized Tactical Fiber Optic Cable.

During this time frame the low temperature impact on cabled fibers was studied. The 12 confirmatory sample cables were completed and shipped. A program was initiated to study the effects of low temperature on various coatings of fibers.

PREFACE

The purpose of this MM&T program is to establish automated production processes for ruggedized tactical fiber optic cables in accordance with specification MM&T-789898 dated 2 February 1978, with Revision 1 dated 1 August 1980, and ECIPPR 15.

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1.0 FABRICATION OF CONFIRMATORY SAMPLE CABLES

During this reporting period the fabrication of the 12 confirmatory sample cables using fibers evaluated in 1100 m increments were completed. The fibers used in this phase were obtained from standard production with high numerical aperatures (NA) (approximately 0.25).

The 12 confirmatory samples were optically, mechanically and environmentally tested in accordance with MM&T Preproduction Test Procedure for Ruggedized Tactical Fiber Optic Cable, ITT Document Identification Number 80-29-09, Revision III. The results of optical, environmental, and mechanical tests performed on confirmatory cables are listed in Appendixes.

All 12 confirmatory sample cables that were optically, mechanically, and environmentally tested pass all specifications except the low temperature impact and the low temperature attenuation. These problems are addressed in paragraph 1.1 and Section 2.0 of this report.

1.1 Low Temperature Study

CECOM and ITT representatives met on 19 February 1982 to review the low temperature performance evaluation of ITT Hytrel®, Nylon 11 and Nylon 12 coated fibers as well as low temperature results achieved with two process cables. CECOM representatives agreed to

allow more time to address the low temperature attenuation increase.

A meeting is scheduled by mid-May between ITT and CECOM to discuss the results of the effort and to reach an agreement on pilot run specifications and schedule.

The MM&T cable program is currently on hold awaiting the results of the low temperature performance evaluation. Hytrel® and Nylon 12 coated fibers jacketed with 1/2 mm and 1 mm outside diameter (od) in the case of Hytrel® and 1 mm od for Nylon will be produced and tested for this study. These fibers will be tested at room temperature, -35°, -45°, and -55°C on tension released spools. The purpose for the use of tension release spools is to lessen the effect of spooling tension on the fiber allowing measurement of the intrinsic characteristics of the fiber. After meeting specifications, these fibers will be incorporated into cables having Kevlar® or rigid center members. These cables will be subjected to optical, mechanical, and low temperature testing in accordance with MM&T Preproduction Test Procedures for Ruggedized Tactical Fiber Optic Cable, ITT Document Identification Number 80-29-09 Revision III.

A total of five cables will be built, each consisting of six fibers around a central member. Table 1.1-1 shows the desired construction.

Table 1.1-1. Desired Cable Construction.

Cable Number	Coating	Central Member
1	940 Hytrel®	Polyurethane coated Kevlar®
2	940 Hytrel®	940 Hytrel® dummy fiber
3	750 Hytrel®	750 μm dummy fiber
4	500 Hytrel®	500 μm dummy fiber
5	940 nylon 12	940 μm dummy fiber

2.0 LOW TEMPERATURE IMPACT STUDY

An intensive study of shattering of the Hytrel® jacket during low temperature impact testing was completed. Six "dummy" MM&T type cables were fabricated for this study.

Three dummy MM&T cables were fabricated and jacketed to various final diameters (0.240, 0.275, 0.310, 0.325) for low temperature impact testing. One cable was constructed of fibers that had been proof-tested at 150 kpsi. The second cable was constructed with standard fibers and the jacket diameter was varied from 0.240 to 0.325 during extrusion. The third cable was constructed with standard fibers and the final jacket extruded in two passes to achieve jacket diameters of 0.275 and 0.325. MM&T cables 3, 5, 6, 7, 8, 10, and 12 of the confirmatory samples were tested in accordance with the Preproduction Test Procedure for Ruggedized Tactical Fiber Optic Cable, ITT Document Indentification Number 80-29-09, Revision III, and DOD-STD-1678, Method 2030, Procedure I. The results of impact testing for the dummy cables and confirmatory samples cables are recorded in Table 2.0-1.

MM&T cables 3, 5, 7, and 10, were dissected to determine the position of the broken fibers. Only 30% of the broken fibers were in the side position, 15% each side, whereas 40% were in the top position and 30% were in the bottom positions. The Hytrel® jacket shattered on each of the broken fibers except one. The Hytrel® coated fibers from cables 3 and 5 were subjected to one coating

Table 2.0-1a. MM&T Cable - Confirmatory Sample Impact Test (3-ft-lb).

Cable	Room Temperature				+71°C				-55°C			
	S	BF	% SF	JS	S	BF	% SF	JS	S	BF	% SF	JS
#3 071881-4C-2	6	0	100	0	6	0	100	0	6	6	83	0
#5 072081-4C-1	6	1	100	0	6	0	100	0	6	6	83	0
#6 071681-4C-1	-	-	-	-	-	-	-	-	6	7	80	0
#7 072081-4C-2	6	0	100	0	6	0	100	0	6	5	86	0
#8 082781-4C-1	-	-	-	-	-	-	-	-	6	11	70	0
#10 091881-4C-2	6	1	97	0	-	-	-	-	6	8	78	0
#12 091781-4C-1	-	-	-	-	-	-	-	-	6	5	86	0

S = no of samples tested.
BF = no of broken fibers.

% SF = percent of surviving fibers = $\frac{S \times 6 - BF}{S \times 6} \times 100$

JS = jacket split.

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Table 2.0-1b. MM&T Cable - Dummy Impact Test.

Cable	0.240 in Diameter				0.275 in Diameter				0.310 in Diameter				0.325 in Diameter			
	S	BF	% SF	JS	S	BF	% SF	JS	S	BF	% SF	JS	S	BF	% SF	JS
09081-4C-1B2	6	8	77	0	-	-	-	-	6	2	94	0	6	1	97	0
101481-4C-1	6	1	97	0	6	2	94	0	6	1	97	0	6	1	97	0
102081-4C-1 (Proof-tested with 150 kpsi)	6	2	94	0	6	2	94	0	6	0	100	0	-	-	-	-

S = no of samples tested.
BF = no of broken fibers.

% SF = percent of surviving fiber = $\frac{S \times 6 - BF}{S \times 6} \times 100$

JS = jacket split.

elongation test and they all showed either low or no elongation of the Hytrel® coating. The lack of elongation of some fiber is because Hytrel® has an excessive crystalline structure with Hytrel® 7246 having the highest crystallization. The extrusion process is being monitored for this condition. The fibers are subject to the elongation test prior to stranding. The fibers in the cables with various diameters that failed the impact test also failed the elongation test.

Three "dummy" MM&T type cables were fabricated using the elongation test for fibers as a criteria. One cable contained all white fibers and the other two were color coded. This was done to see if color coding was affecting the Hytrel®. The cables were tested in accordance with Preproduction Test Procedure for Ruggedized Tactical Fiber Optic Cable, ITT Document Identification Number 80-29-09, Revision III, and DOD-STD-1678, Method 2030, Procedure I. The results of the impact testing are recorded in Table 2.0-2.

Using the elongation test for fibers as a criteria, it is evident that the cables will pass impact test without affecting the Hytrel® jacket.

Fibers were extruded with six temperature profiles to determine if there is any correlation with the shattering of the Hytrel® during low temperature impact testing. These fibers were sent to Dupont for analyzing.

Table 2.0-2. MM&T Cable - Impact Test.

Dummy Cable	S	0.245 in Dia BF	-55°C % SF	Impact 3 ft• lb JS	Elongation Test	Prior to Cabling
110481-4C-1	6	0	100	0	Passed	Color coded fibers
110981-4C-1	6	0	100	0	Passed	All white fibers
110981-4C-2	6	0	100	0	Passed	Color coded fibers

S = no of samples tested.

BF = no of broken fibers.

% SF = percent of surviving fibers = $\frac{S \times 6 - BF}{S \times 6} \times 100$

JS = jacket split.

Dupont's preliminary report to ITT indicated that there was no appreciable difference in the Hytrel® at the six temperature profiles.

3.0 CABLE MANUFACTURING PROCESS, EQUIPMENT, TOOLING, AND MEASUREMENTS

This section describes the manufacturing process, equipment, and tooling used to manufacture the MM&T cable as well as optical evaluation of cables.

3.1 Cable Manufacturing Process

The basic MM&T cable design is shown in Figure 3.1-1. The cable fabrication flow chart is shown in Figure 3.1-2.

The MM&T cable optical core contains six optical fibers contrahelically laid around a polyurethane coated Kevlar® central member. A jacket of polyurethane is extruded over the optical core. Then the jacketed optical core is served with 18-Kevlar® strength members before a final jacket of polyurethane is applied.

3.1.1 Fiber Rewind Station

This station (Figure 3.1-2, Operation E1) is used to respool and inspect fibers in preparation for the subsequent stranding operation. The equipment consists of a rewinder, an optical lump detector to examine the fiber buffer jacket for any nonuniformities, and a constant-tension compensating payoff to eliminate fiber breaks.

This unit is also used to visually inspect fibers for buffer jacket flaws.

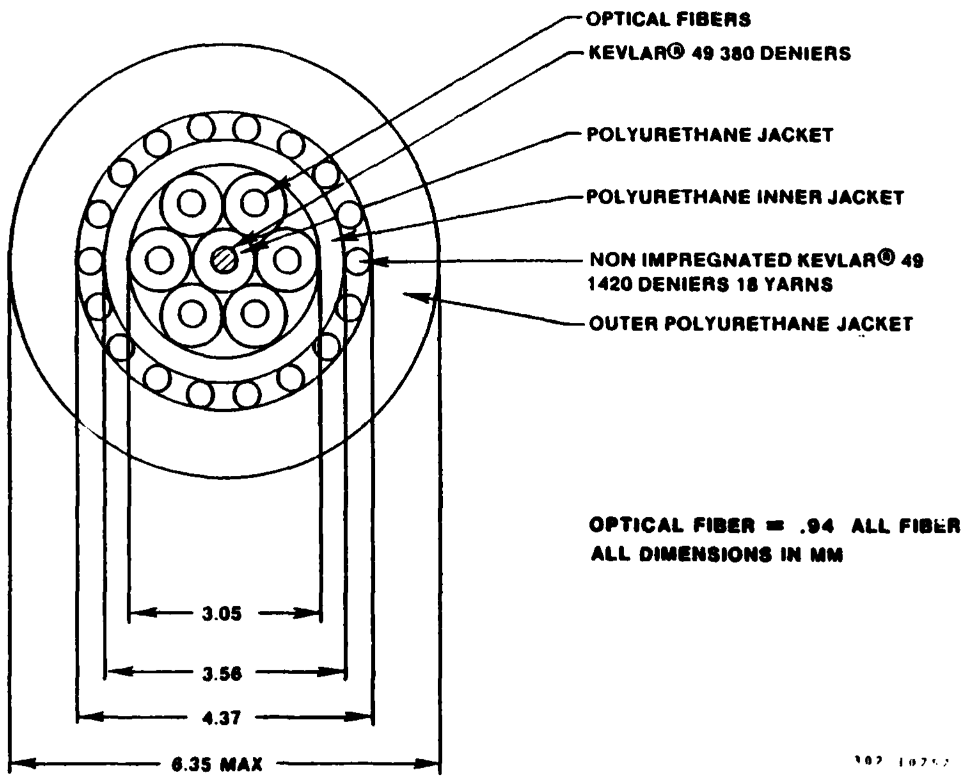

Figure 3.1-1. Basic MM&T Cable Design.

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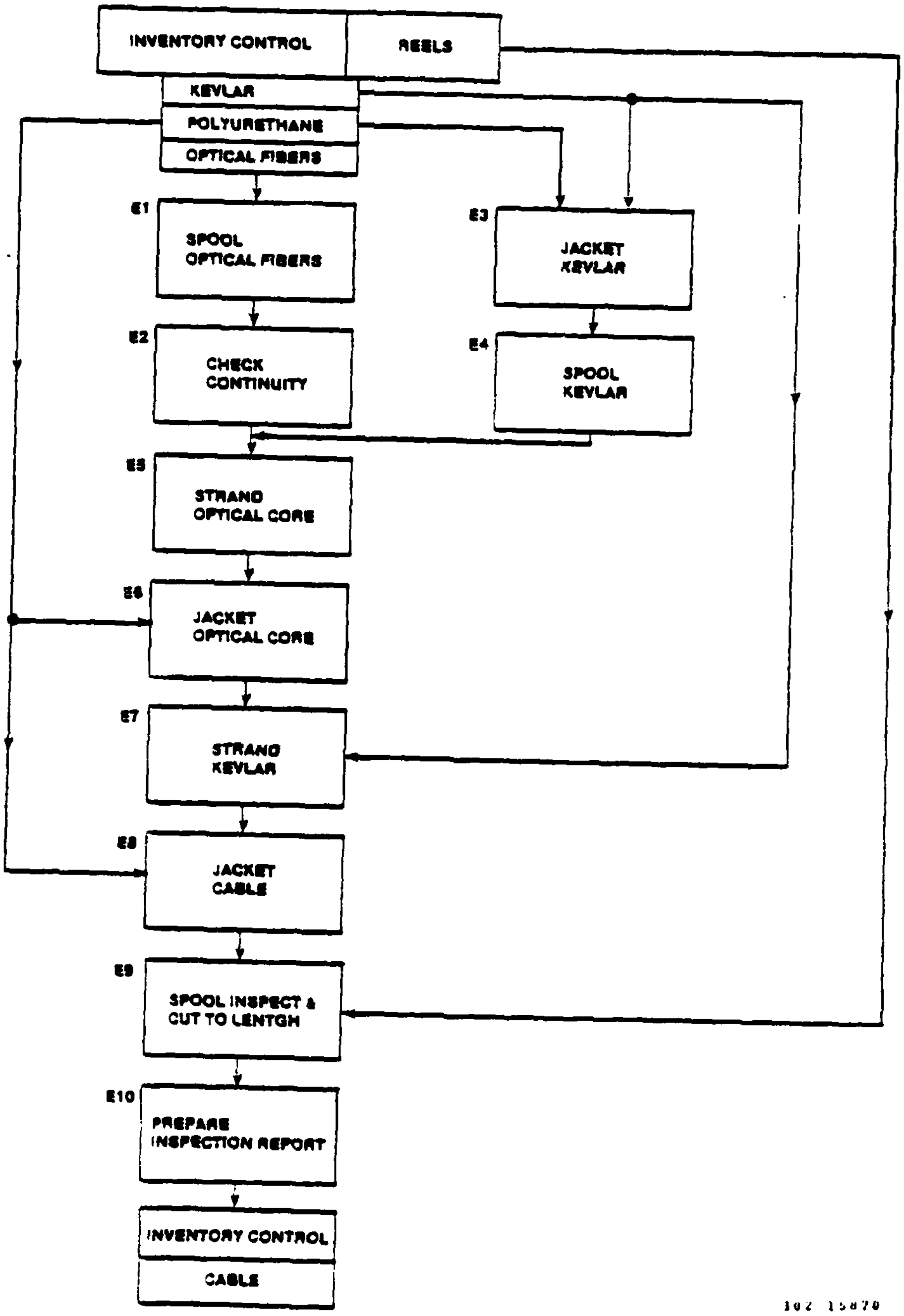

Figure 3.1-2. Cable Fabrication Flow Chart.

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3.1.2 Fiber Continuity Check Station

Before fibers are stranded into a cable bundle, continuity of each fiber is tested and any defects or broken fibers are removed. The unit used at this station (Figure 3.1-2, Operation E2) is an instrument designed for detecting and locating faults in optical fibers for measuring their length and for analyzing their transmission characteristics. The instrument operates by launching a pulse of laser light into the fiber and monitoring the amplitude and time delay of events in the light reflected back along the fiber.

3.1.3 Kevlar® Jacketing Station

This station (Figure 3.1-2, Operation E3) is used to overcoat a Kevlar® 49-380 denier yarn with a polyurethane jacket which is used as the central core for the optical bundle. A 1-in extruder is used to pressure extrude the polyurethane jacket at a rate of 76 m/min. An automatic diameter control unit is used which measures the extruded jacket diameter of the core element and regulates the line speed to provide a constant diameter over the existing cable length.

3.1.4 Respooling Station for Polyurethane Jacketed Kevlar® Central Member

The identical equipment as used for the fiber rewind operation (paragraph 3.1.1) is employed. The capacity of this unit is ample

to perform both fiber rewind and center member respooling operations.

3.1.5 Optical Core Stranding Station

This station is used (Figure 3.1-2, Operation E5) to strand six optical fibers helically around the polyurethane Kevlar® jacketed center member. A high speed single twist closing unit equipped with a 13-bay neutralizing unit is employed. The unit operates at 1800 m/h.

3.1.6 Optical Core Jacketing Station

Station E6 in Figure 3.1-2 is used to extrude the polyurethane jacket over the optical core. The jacket is applied with a 1-1/2-in extrusion line capable of extruding the first jacket at 68 m/min.

3.1.7 Kevlar® Stranding Station

Station E7 in Figure 3.1-2 is employed to strand 18 Kevlar® strength members around the jacketed optical core. The Kevlar® stranding machine contrahelically serves the 18 Kevlar® strength members around the optical core. The Kevlar® serving line is capable of stranding Kevlar® at 10 m/min.

3.1.8 Final Jacketing Station

A 2-in extrusion line (Figure 3.1-2, Operation E8) is used to extrude the final cable jacket. The extrusion line is capable of

extruding the final jacket at 42 m/min which is double the rate required for the MM&T program.

3.1.9 Final Cable Respooling Station

The cable is respooled on the Federal cable rewinder (Figure 3.1-2, Operation E9) for shipping. This machine enables an inspector to visually inspect the cable for anomalies and irregularities while being spooled on the DR-5 reel.

3.2 Optical Evaluation of MM&T Cables

3.2.1 Attenuation Test

The attenuation tests are performed by the cutback method. This procedure is described in the test report for phase 3 MM&T cables in Appendix A. The optical attenuation of each cabled fiber is measured at six selected wavelengths: 8,200; 8,500; 10,600; 11,000; 12,000; and 13,000 Å. All the cable samples are tested to meet the <5 dB/km attenuation requirement.

The calculation procedure followed Method 6020 of MIL-STD-1678. The output through the fiber is measured at 0.82 μm for injection numerical apertures of 0.89, 0.124, 0.176, and 0.243. The attenuation at each of the remaining five wavelengths was measured at an injected NA of 0.089. The single injection NA is selected to avoid changing injection NA conditions at each wavelength thereby eliminating input variation between the short and long length measurements.

Once the output through the long length is measured at the specified wavelengths, the fiber is cut at a distance of 1 m from the injection end. A new end is prepared on the output end of the reference length and the measurement repeated for the short length. The attenuation test setup is shown in Figure 3.2.1-1.

3.2.2 Pulse Dispersion

The MM&T cables are tested for pulse dispersion to determine if the requirement of 2 ns/km maximum is met. The 50% (3 dB) optical pulse dispersion of the test fiber is measured using existing equipment (Figure 3.2.2-1) operating at 9000 Å. Method 6050 of DOD-STD-1678 is utilized.

3.2.3 Numerical Aperture (NA)

The MM&T cables are tested to determine if the NA requirement of >0.17 is met. The exit NA, defined as sin $\phi/2$ where ϕ is the core angle containing 90% of the output power of each cabled fiber, was measured at a wavelength of 0.82 μm. The numerical aperture station is illustrated in Figure 3.2.3-1.

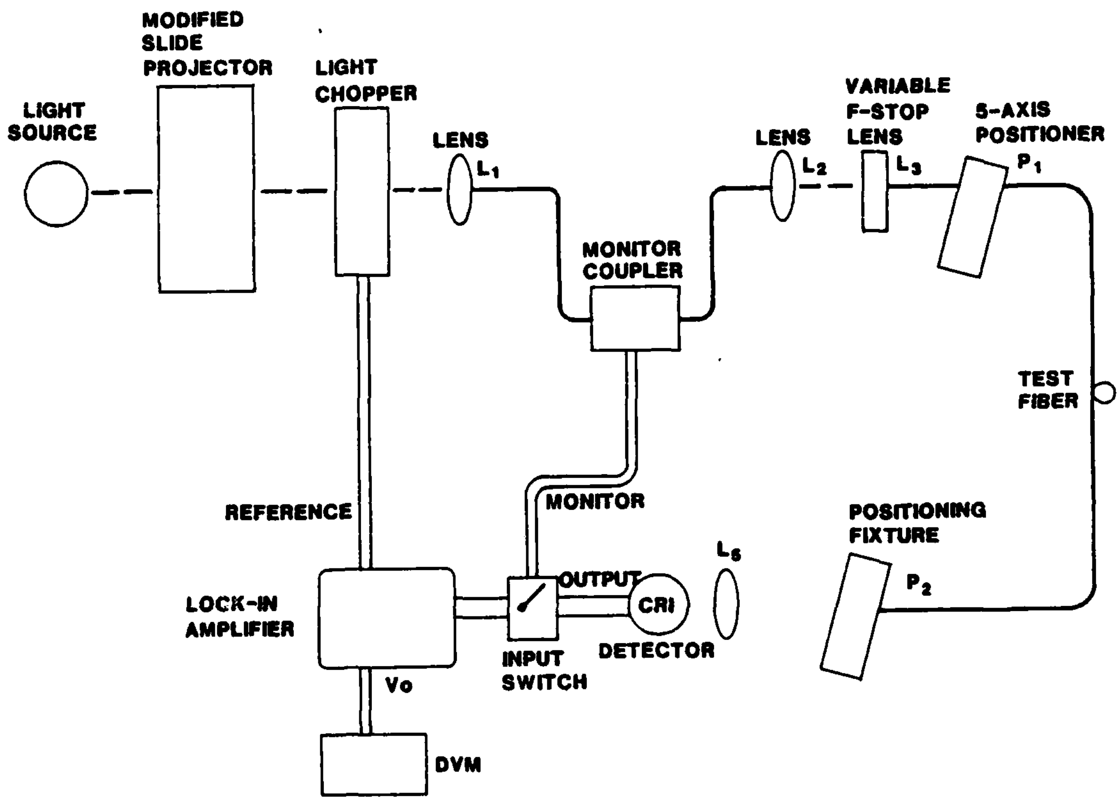

Figure 3.2.1-1. Attenuation Test Setup.

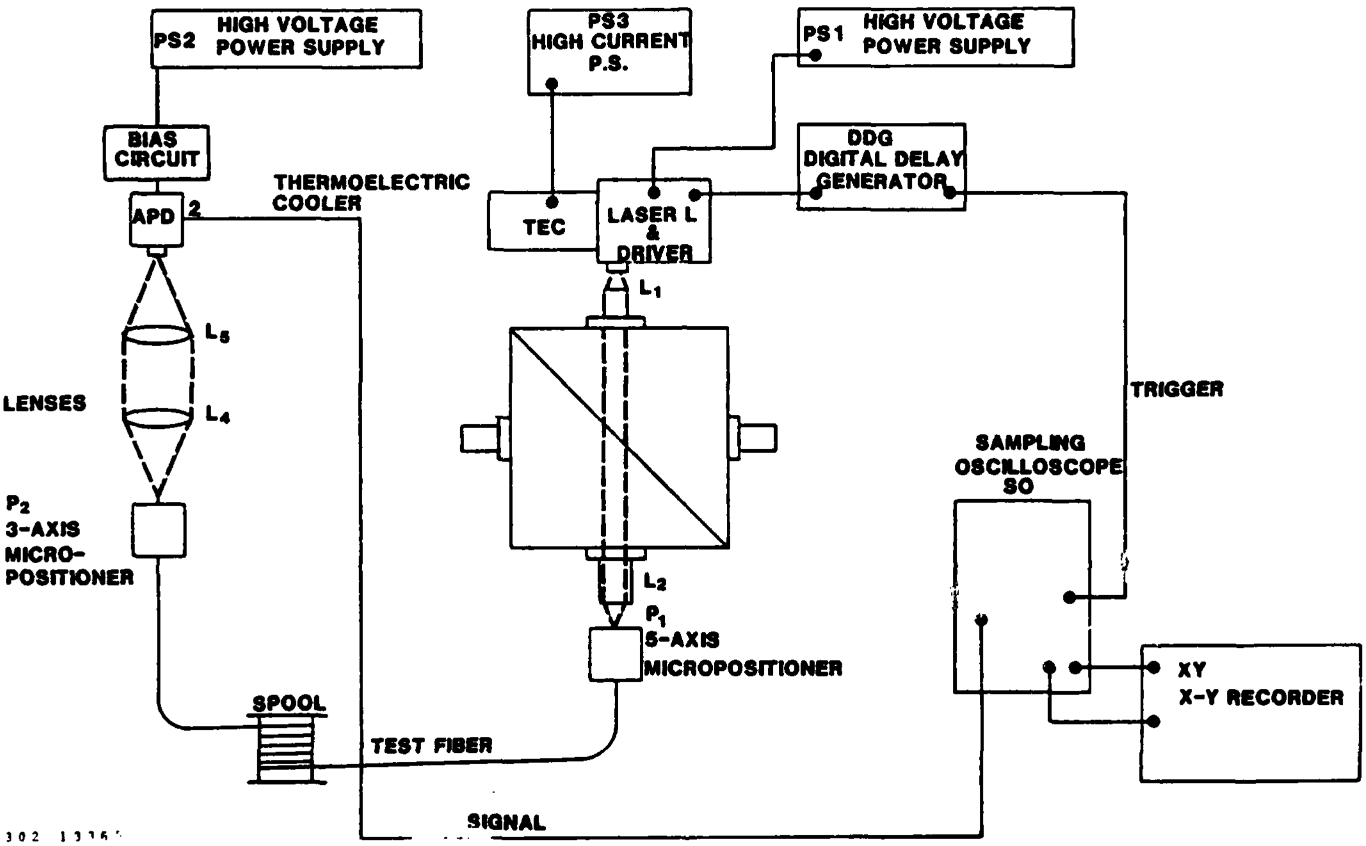

Figure 3.2.2-1. Pulse Dispersion Test Setup.

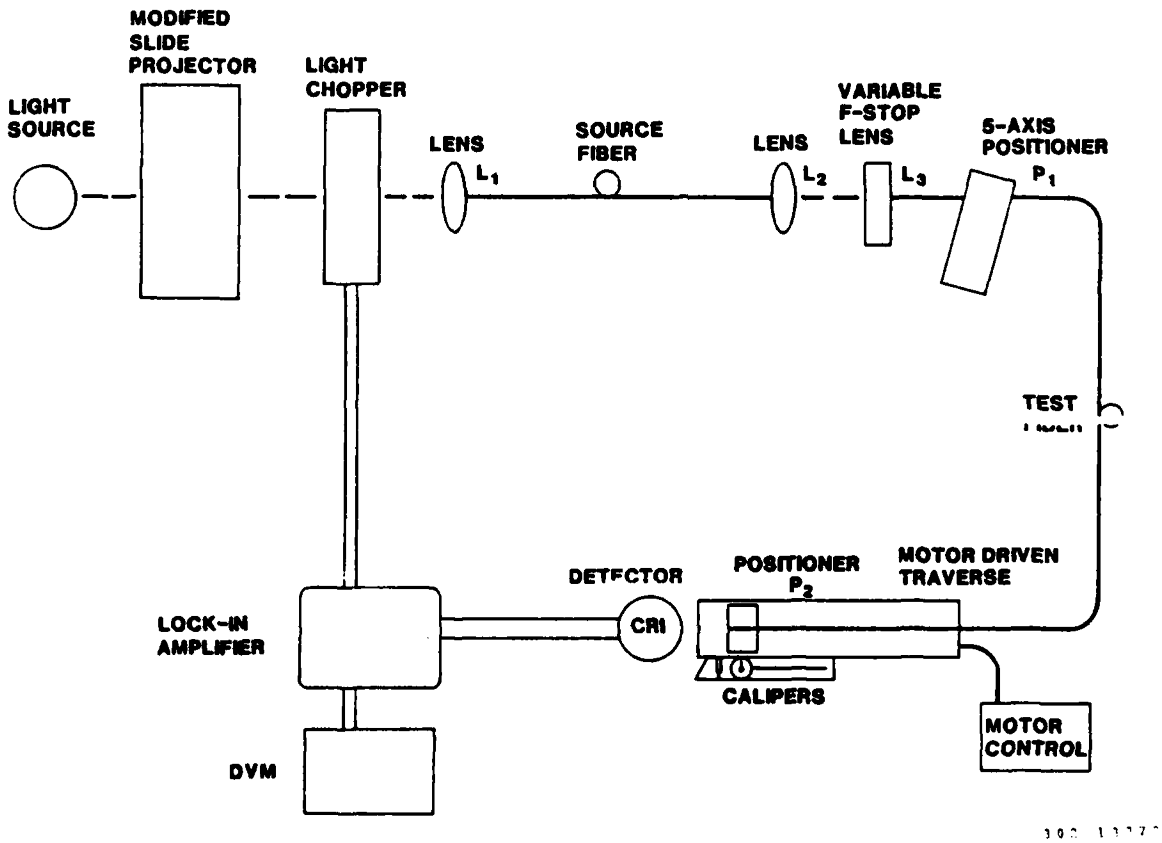

Figure 3.2.3-1. Test Setup for 90% Power Numerical Aperture.

4.0 SUMMARY OF ACCOMPLISHMENTS

The objectives of the work performed during this reporting period were to (a) study the low temperature impact on cabled fibers, (b) fabricate, evaluate, and ship the 12 confirmatory sample cables, and (c) initiate a program to study the effects of low temperature on various coatings of fibers.

An intensive study of the shattering of the Hytrel® jacket during low temperature impact testing was completed. Six dummy MM&T type cables were fabricated for this study. A set of three dummy MM&T type cables were fabricated and jacketed to various final diameters (0.240 in, 0.275 in, 0.310 in, 0.325 in) for low temperature impact testing. MM&T cables 3, 5, 6, and 10 were dissected to determine the position of the broken fibers. There were 30% of the fibers broken on the bottom positions compared with 40% of the fibers broken in the top position. Only 30% of the broken fibers were in the side position, 15% each side. Another set of three dummy MM&T type cables were fabricated using the elongation test for fibers as a criteria. All these cables passed the low temperature impact test. Fiber was sent to Dupont for analyzing of extrusion temperature profiles to determine if there is any correlation with the shattering of Hytrel® during low temperature impact testing. Dupont's preliminary report indicated no appreciable difference.

Numerical aperture is the single most important variable affecting low temperature loss; however, there are other variables relating coating quality to low temperature loss. The coefficient of expansion for the secondary coating and the glass fiber are different, therefore coating thickness, coating eccentricity, cooling rate, and draw down ratio of the extruder tooling must be controlled. Draw down ratio and cooling rate have been chosen to reduce internal stress buildup in the secondary coating while maintaining acceptable draw speed. Thickness and eccentricity are monitored to assure uniformity and adherence to acceptable tolerances. When all of these variables are balanced properly, the result is a coating that does not introduce excessive stress on the fiber due to contraction at low temperature. The high NA fiber is less sensitive to loss due to microbending arising from stress.

All 12 confirmatory cables were optically, mechanically, and environmentally tested and shipped to CECOM. These cables passed all optical, mechanical, and environmental specifications except the low temperature impact and the low temperature attenuation.

A meeting with CECOM and ITT representatives was held on February 19, 1982, to review the low temperature performance evaluation of ITT Hytrel® and Nylon 11 and Nylon 12 coated fibers as well as low temperature results achieved with the two process cables. More time was allowed to address the low temperature attenuation

increase. A meeting is scheduled by mid-May to discuss the results of the effort and to reach an agreement on pilot run specifications and schedule.

5.0 PERSONNEL

5.1 Key Personnel Man-Hours

The key personnel involved in the MM&T program and their hours expended during this period are described in Table 5.1-1.

Table 5.1-1. Key Personnel and Hours Expended.

Name	Responsibility	Man-Hours Expended
R. Coon	Program Management	190
J. Smith	Senior project engineer	30
D. Taylor	Cable production	210

APPENDIX A

OPTICAL TEST DATA

Table A-1. Dimensional Measurements.

Fiber Identification	CVD Number	Core Diameter (μm) SOP*	Core Diameter (μm) EOP**	Cladding Diameter (μm) SOP*	Cladding Diameter (μm) EOP**
Cable 1: 071781-4C-1					
1 Blue	HG-090229	51 x 50	45 x 48	126	126
2 Orange	HG-090229	51 x 50	45 x 48	126	126
3 Brown	HG-090380	49	49	128	126 x 124
4 White	HG-090330	51 x 50	49 x 48	124	123 x 122
5 Slate	HG-090286	53	53 x 52	126	124
6 Green	HG-090289	53 x 52	51 x 54	125	126
Cable 2: 071881-4C-1					
1 Blue	HG-090311	51 x 50	51 x 50	124 x 123	124 x 122
2 Orange	HG-090329	51	52 x 51	125 x 124	123 x 122
3 Brown	HG-090286	53 x 52	53	126	126
4 White	HG-090286	53	53 x 52	126	124
5 Slate	HG-090266	49 x 47	51 x 50	126	127 x 126
6 Green	HG-090359	49	50	126	128 x 126

* Start of pull, bottom spool.
** End of pull, top of spool.

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Table A-1. Dimensional Measurements (continued).

Cable 3: 071881-4C-2

Fiber Identification		CVD Number	Core Diameter (μm) SOP*	Core Diameter (μm) EOP**	Cladding Diameter (μm) SOP*	Cladding Diameter (μm) EOP**
1	Blue	HG-090192	50 x 48	47 x 45	126 x 125	126
2	Orange	HG-090240	50 x 49	50 x 49	125 x 124	125 x 124
3	Brown	HG-090418	47 x 45	48	126	126
4	White	HG-090228	50	49 x 46	124 x 123	125 x 124
5	Slate	HG-090236	51 x 49	51 x 49	126 x 124	125 x 124
6	Green	HG-090311	51 x 50	51 x 50	124 x 123	124 x 122
Cable 4: 071881-4C-3						
1	Blue	HG-090272	49 x 48	49 x 48	127 x 124	126
2	Orange	HG-090258	50 x 47	50 x 47	126 x 125	126 x 124
3	Brown	HG-090273	53	51 x 50	126 x 124	126 x 124
4	White	HG-090267	49 x 46	52 x 51	127 x 126	127 x 125
5	Slate	HG-090289	53 x 52	51 x 54	125	126
6	Green	HG-090248	50 x 49	49 x 48	126 x 125	126 x 125

* Start of pull, bottom spool.
** End of pull, top of spool.

Table A-1. Dimensional Measurements (continued).

Fiber Identification	CVD Number	Core Diameter (μm) SOP*	Core Diameter (μm) EOP**	Cladding Diameter (μm) SOP*	Cladding Diameter (μm) EOP**
Cable 5: 072081-4C-1					
1 Blue	HG-090238	49 x 48	50 x 48	124 x 123	126 x 124
2 Orange	HG-090285	52 x 53	51 x 52	123 x 124	124 x 125
3 Brown	HG-090385	48	50 x 48	126 x 125	126
4 White	HG-090287	52 x 51	52 x 50	126 x 124	126 x 124
5 Slate	HG-090386	49 x 48	50 x 49	125 x 126	126
6 Green	HG-090357	52 x 50	50 x 49	127	127 x 126
Cable 6: 071681-4C-1					
1 Blue	HG-090261	50 x 47	49 x 46	126 x 124	126 x 124
2 Orange	HG-090202	49 x 46	46	125 x 124	125 x 124
3 Brown	HG-090240	50 x 49	50 x 49	125 x 124	124 x 123
4 White	HG-090273	51 x 50	53	126 x 124	126 x 125
5 Slate	HG-090236	49 x 47	49 x 48	123 x 122	124
6 Green	HG-090189	51 x 50	51 x 50	128	128 x 127

* Start of pull, bottom spool.
** End of pull, top of spool.

Table A-1. Dimensional Measurements (continued).

Fiber Identification	CVD Number	Core Diameter (μm) SOP*	Core Diameter (μm) EOP**	Cladding Diameter (μm) SOP*	Cladding Diameter (μm) EOP**
Cable 7: 072081-4C-2					
1 Blue	HG-090375	53 x 52	53 x 51	128 x 127	127 x 126
2 Orange	HG-090385	48	50 x 48	126 x 125	126
3 Brown	HG-090300	54 x 51	54 x 51	129	127 x 126
4 White	HG-090395	48 x 47	49 x 49	127 x 126	125 x 123
5 Slate	HG-090232	50 x 49	50 x 48	126 x 125	124 x 123
6 Green	HG-090197	49	50 x 49	126	125
Cable 8: 082781-4C-1					
1 Blue	HG-090222	48 x 46	48 x 47	126 x 125	127 x 126
2 Orange	HG-100499B	52 x 50	54 x 53	126	126 x 125
3 Brown	HG-090352	53 x 51	50 x 48	126	127 x 126
4 White	HG-120079	52 x 51	51	126 x 124	126 x 123
5 Slate	HG-090394	51 x 50	50 x 49	127 x 127	127 x 126
6 Green	HG-090244	52 x 51	51 x 50	126 x 125	126

* Start of pull, bottom spool.
** End of pull, top of spool.

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Table A-1. Dimensional Measurements (continued).

Fiber Identification		CVD Number	Core Diameter (μm) SOP*	Core Diameter (μm) EOP**	Cladding Diameter (μm) SOP*	Cladding Diameter (μm) EOP**
Cable 9: 102781-4C-1						
1	Blue	HG-120188	52 x 51	49 x 48	123 x 124	123 x 123
2	Orange	HG-090618	52 x 50	50	128 x 126	126 x 124
3	Brown	HG-090681	49 x 49	50 x 49	125 x 125	127 x 126
4	White	HG-100615	53 x 52	52 x 51	128 x 126	127 x 125
5	Slate	HG-090618	52 x 50	50	128 x 126	126 x 124
6	Green	HG-090223	49 x 48	50 x 48	125 x 124	127 x 126
Cable 10: 091881-4C-2						
1	Blue	HG-090354	50 x 49	52 x 51	128 x 127	126
2	Orange	HG-090314	50 x 49	49 x 48	124	123 x 122
3	Brown	HG-100528	52 x 51	52 x 51	126	126
4	White	HG-100528	52 x 51	51 x 51	126	126
5	Slate	HG-100528	48 x 50	50 x 51	123 x 124	125 x 127
6	Green	HG-090456	55 x 52	51 x 50	126 x 124	127 x 125

* Start of pull, bottom spool.
** End of pull, top of spool.

Table A-1. Dimensional Measurements (continued).

Cable 11: 112381-4C-1

Fiber Identification		CVD Number	Core Diameter (μm) SOP*	Core Diameter (μm) EOP**	Cladding Diameter (μm) SOP*	Cladding Diameter (μm) EOP**
1	Blue	HG-100638	52 x 50	54 x 51	125	125 x 124
2	Orange	HG-120280	51 x 48	49 x 48	123 x 122	124
3	Brown	HG-120280	51 x 48	49 x 48	123 x 122	124
4	White	HG-100638	52 x 50	54 x 51	125	125 x 124
5	Slate	HG-120280	51 x 48	49 x 48	123 x 122	124
6	Green	HG-120274	52 x 51	51 x 50	126 x 124	126 x 124

Cable 12: 091781-4C-1

Fiber Identification		CVD Number	Core Diameter (μm) SOP*	Core Diameter (μm) EOP**	Cladding Diameter (μm) SOP*	Cladding Diameter (μm) EOP**
1	Blue	HG-090594	49 x 50	50 x 51	124 x 126	124 x 125
2	Orange	HG-120132	51 x 50	49 x 48	125 x 124	124 x 123
3	Brown	HG-100524	51 x 49	48	125 x 123	126 x 124
4	White	HG-090328	49	50 x 49	123	124 x 122
5	Slate	HG-100524	52 x 54	52	126	125
6	Green	HG-120150	53 x 52	51 x 51	123 x 123	124 x 123

* Start of pull, bottom spool.
** End of pull, top of spool.

Table A-2. Cable Results, Cable 1 and Cable 2.

Fiber Identification		CVD Number	Attenuation (dB/km) at 850 nm* Before Cabling	After Cabling	Δ	Dispersion (ns/km) at 900 nm Before Cabling	After Cabling	Δ
Cable 1: 071781-4C-1								
1	Blue	HG-090229	3.65	3.09	-0.56	0.36	0.37	+0.01
2	Orange	HG-090229	3.65	3.25	-0.40	0.36	0.51	+0.15
3	Brown	HG-090380	3.14	3.07	-0.07	0.93	1.09	+0.16
4	White	HG-090330	2.94	2.55	-0.39	0.52	1.52	+1.00
5	Slate	HG-090286	3.43	3.15	-0.28	0.76	1.35	+0.59
6	Green	HG-090289	3.42	3.30	-0.12	0.33	0.52	+0.19
	Average		3.37	3.06	-0.30	0.54	0.89	+0.35
Cable 2: 071881-4C-1								
1	Blue	HG-090311	3.47	4.22	+0.73	1.03	0.94	-0.09
2	Orange	HG-090329	3.52	3.68	+0.16	0.72	0.77	+0.05
3	Brown	HG-090286	2.94	3.04	+0.10	0.52	0.72	+0.20
4	White	HG-090286	2.94	3.32	+0.38	0.52	0.84	+0.32
5	Slate	HG-090266	3.12	3.87	+0.75	1.34	1.39	+0.05
6	Green	HG-090359	3.31	2.84	-0.47	0.97	0.48	-0.49
	Average		3.21	3.49	+0.28	0.85	0.87	+0.02

*Fibers drawn from inventory are measured at 850 nm.

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Table A-3. Cable Results, Cable 3 and Cable 4.

Fiber Identification	CVD Number	Attenuation (dB/km) at 850 nm* Before Cabling	After Cabling	Δ	Dispersion (ns/km) at 900 nm Before Cabling	After Cabling	Δ
Cable 3: 071881-4C-2							
1 Blue	HG-090192	3.29	3.23	-0.06	0.44	0.55	+0.11
2 Orange	HG-090240	3.15	3.40	+0.25	0.31	0.52	+0.21
3 Brown	HG-090418	3.34	3.15	-0.19	0.68	0.55	-0.13
4 White	HG-090228	3.20	3.56	+0.36	0.60	0.50	-0.10
5 Slate	HG-090236	3.23	4.11	+0.88	0.34	0.67	+0.33
6 Green	HG-090311	3.47	3.93	+0.46	1.03	1.20	+0.17
Average		3.28	3.56	+0.28	0.56	0.66	+0.10
Cable 4: 071881-4C-3							
1 Blue	HG-090277	3.46	3.52	+0.06	0.88	1.09	+0.21
2 Orange	HG-090258	3.65	3.74	+0.09	0.27	0.35	+0.08
3 Brown	HG-090273	3.08	3.13	+0.05	0.75	0.62	-0.13
4 White	HG-090267	3.40	3.40	0.00	0.55	1.22	+0.67
5 Slate	HG-090289	3.42	3.44	+0.02	0.33	0.56	+0.23
6 Green	HG-090248	3.07	3.31	+0.24	0.64	0.56	-0.08
Average		3.35	3.42	+0.07	0.57	0.73	+0.16

*Fibers selected from inventory are measured at 850 nm.

Table A-4. Cable Results, Cable 5 and Cable 6.

Fiber Identification		CVD Number	Attenuation (dB/km) at 850 nm* Before Cabling	After Cabling	Δ	Dispersion (ns/km) at 900 nm Before Cabling	After Cabling	Δ
Cable 5: 072081-4C-1								
1	Blue	HG-090238	4.67	4.53	-0.14	0.92	0.76	-0.16
2	Orange	HG-090285	3.19	3.50	+0.31	1.05	1.37	+0.32
3	Brown	HG-090385	3.34	3.38	+0.04	0.82	1.46	+0.64
4	White	HG-090287	3.23	3.66	+0.43	0.48	0.98	+0.50
5	Slate	HG-090386	3.65	3.63	-0.02	1.09	1.61	+0.52
6	Green	HG-090357	3.21	3.43	+0.22	0.83	0.68	-0.15
	Average		3.55	3.69	+0.14	0.87	1.14	+0.27
Cable 6: 071681-4C-1								
1	Blue	HG-090261	3.30	3.21	-0.09	0.32	0.32	0.00
2	Orange	HG-090202	3.14	3.14	0.00	0.72	0.72	0.00
3	Brown	HG-090240	3.15	3.08	-0.07	0.31	0.51	+0.20
4	White	HG-090273	3.08	2.82	-0.18	0.75	0.21	-0.54
5	Slate	HG-090236	3.20	2.94	-0.26	0.64	0.69	+0.05
6	Green	HG-090189	3.82	4.07	+0.25	0.63	0.65	+0.02
	Average		3.28	3.21	-0.07	0.56	0.52	-0.04

*Fibers selected from inventory are measured at 850 nm.

Table A-5. Cable Results, Cable 7 and Cable 8.

Fiber Identification		CVD Number	Attenuation (dB/km) at 850 nm* Before Cabling	After Cabling	Δ	Dispersion (ns/km) at 900 nm Before Cabling	After Cabling	Δ
Cable 7: 072081-4C-2								
1	Blue	HG-090375	3.30	3.42	+0.12	0.77	1.00	+0.23
2	Orange	HG-090385	3.25	3.40	+0.15	0.82	1.22	+0.40
3	Brown	HG-090300	3.85	4.18	+0.33	0.25	0.37	+0.12
4	White	HG-090395	3.11	3.34	+0.23	0.89	0.87	+0.02
5	Slate	HG-090232	3.91	4.11	+0.20	0.39	0.69	+0.30
6	Green	HG-090197	4.00	3.73	-0.27	0.47	0.57	+0.10
	Average		3.57	3.69	+0.12	0.60	0.79	+0.19
Cable 8: 082781-4C-1								
1	Blue	HG-090222	3.48	3.31	-0.17	1.03	1.45	+0.42
2	Orange	HG-100499B	2.87	2.95	+0.08	0.81	0.81	0.00
3	Brown	HG-090352	3.13	3.29	+0.16	0.95	0.62	-0.33
4	White	HG-120079	2.62	3.62	+1.00	0.98	1.41	+0.43
5	Slate	HG-090394	3.99	3.94	-0.05	0.70	1.16	+0.46
6	Green	HG-090244	3.89	3.87	-0.02	0.64	0.66	+0.02
	Average		3.33	3.50	+0.17	0.85	1.01	+0.16

*Fibers selected from inventory are measured at 850 nm.

Table A-6. Cable Results, Cable 9 and Cable 10.

Fiber Identification		CVD Number	Attenuation (dB/km) at 850 nm* Before Cabling	After Cabling	Δ	Dispersion (ns/km) at 900 nm Before Cabling	After Cabling	Δ
			Cable 9: 102781-4C-1					
1	Blue	HG-120188	3.37	2.95	-0.42	0.31	0.68	+0.37
2	Orange	HG-090618	2.93	4.29	+1.36	0.55	0.79	+0.24
3	Brown	HG-0901681	3.23	3.34	+0.11	1.13	0.97	-0.16
4	White	HG-100615	3.28	3.38	+0.10	0.51	1.44	+0.93
5	Slate	HG-090618	4.22	3.80	-0.42	0.37	0.68	+0.31
6	Green	HG-090223	3.67	3.98	+0.31	0.84	0.88	+0.04
	Average		3.45	3.62	+0.17	0.61	0.90	+0.29
			Cable 10: 091881-4C-2					
1	Blue	HG-090354	3.39	3.64	+0.25	1.17	1.05	-0.12
2	Orange	HG-090314	3.68	3.34	-0.34	1.39	1.00	-0.39
3	Brown	HG-100528	2.52	4.30	+1.78	1.55	0.43	-1.12
4	White	HG-100528	3.48	2.96	0.52	1.37	1.04	-0.33
5	Slate	HG-100528	3.39	4.01	+0.61	1.57	0.52	-1.05
6	Green	HG-090456	4.26	3.67	-0.59	1.29	1.49	+0.20
	Average		3.45	3.65	+0.20	1.39	0.92	-0.47

*Fibers selected from inventory are measured at 850 nm.

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Table A-7. Cable Results, Cable 11 and Cable 12.

Fiber Identification		CVD Number	Attenuation (dB/km) at 850 nm* Before Cabling	After Cabling	Δ	Dispersion (ns/km) at 900 nm Before Cabling	After Cabling	Δ
Cable 11: 112381-4C-1								
1	Blue	HG-100638	2.99	3.80	+0.81	0.48	0.92	+0.44
2	Orange	HG-120280	3.06	3.43	+0.37	0.66	0.61	-0.05
3	Brown	HG-120280	3.06	3.62	+0.56	0.66	0.63	-0.03
4	White	HG-100638	2.99	3.19	+0.20	0.98	1.20	+0.22
5	Slate	HG-120280	3.49	3.83	+0.34	0.52	0.73	+0.21
6	Green	HG-120274	3.15	3.23	+0.08	1.17	1.18	+0.01
	Average		3.12	3.51	+0.39	0.75	0.88	+0.13
Cable 12: 091781-4C-1								
1	Blue	HG-090594	2.97	4.19	+1.22	0.46	0.70	+0.23
2	Orange	HG-120132	3.06	3.03	-0.03	0.66	1.20	+0.54
3	Brown	HG-100524	3.23	3.00	-0.23	0.73	0.72	-0.01
4	White	HG-090328	3.48	3.37	-0.11	0.81	0.70	-0.11
5	Slate	HG-100524	3.34	3.70	+0.36	0.80	1.18	+0.38
6	Green	HG-120150	3.24	3.03	-0.21	0.95	0.71	-0.24
	Average		3.22	3.38	+0.16	0.73	0.86	+0.13

*Fibers selected from inventory are measured at 850 nm.

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Table A-8. Attenuation Versus Wavelength After Cabling (dB/km).*

Fiber Identification	CVD Number	Wavelength (nm) 820	850	1060	1100	1200	1300
Cable 1: 071781-4C-1							
1 Blue	HG-090229	3.63	3.09	1.3	1.2	1.05	1.87
2 Orange	HG-090229	3.74	3.25	1.65	1.25	1.12	1.51
3 Brown	HG-090380	3.60	3.07	1.41	1.24	1.09	1.30
4 White	HG-090330	4.05	2.55	1.68	1.61	1.42	1.66
5 Slate	HG-090286	3.53	3.15	1.38	1.32	1.12	1.54
6 Green	HG-090289	4.82	3.30	3.17	2.43	2.13	1.58
Cable 2: 071881-4C-1							
1 Blue	HG-090311	4.75	4.22	2.33	2.05	1.73	2.17
2 Orange	HG-090329	4.24	3.68	2.05	1.90	1.60	1.37
3 Brown	HG-090286	3.41	3.04	1.53	1.33	1.11	1.46
4 White	HG-090286	3.81	3.32	1.57	1.47	1.13	2.10
5 Slate	HG-090266	4.15	3.87	2.02	1.82	1.67	1.23
6 Green	HG-090359	3.39	2.84	1.09	0.96	0.8	1.28

*Injected NA 0.089.

Table A-8. Attenuation Versus Wavelength After Cabling (dB/km) (continued).*

Fiber Identification		CVD Number	Wavelength (nm) 820	850	1060	1100	1200	1300
			Cable 3: 071881-4C-2					
1	Blue	HG-090192	3.86	3.23	1.50	1.34	1.14	1.42
2	Orange	HG-090240	3.94	3.40	1.68	1.50	1.59	3.03
3	Brown	HG-090418	3.55	3.15	1.78	1.32	1.21	0.75
4	White	HG-090228	4.02	3.56	1.59	1.50	1.24	1.23
5	Slate	HG-090236	4.46	4.11	2.39	2.03	1.77	0.66
6	Green	HG-090311	4.27	3.93	1.87	1.47	1.11	1.41
			Cable 4: 071881-4C-3					
1	Blue	HG-090272	4.08	3.52	1.56	1.51	1.19	1.19
2	Orange	HG-090258	4.19	3.74	1.85	1.72	1.50	1.36
3	Brown	HG-090273	3.69	3.13	1.20	1.11	0.90	1.01
4	White	HG-090267	3.95	3.40	1.65	1.53	1.30	1.25
5	Slate	HG-090289	3.94	3.44	1.73	1.65	1.37	1.24
6	Green	HG-090248	3.83	3.31	1.60	1.45	1.22	0.89

*Injected NA 0.089.

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Table A-8. Attenuation Versus Wavelength After Cabling (dB/km) (continued).*

Cable 5: 072081-4C-1

Fiber Identification		CVD Number	Wavelength (nm) 820	850	1060	1100	1200	1300
1	Blue	HG-090238	5.02	4.53	2.67	2.58	2.36	2.65
2	Orange	HG-090285	3.73	3.50	1.14	0.93	0.68	0.42
3	Brown	HG-090385	3.91	3.38	1.58	1.43	1.25	1.15
4	White	HG-090287	4.12	3.66	1.73	1.61	1.17	1.26
5	Slate	HG-090386	4.31	3.63	1.39	1.14	0.78	0.57
6	Green	HG-090357	3.92	3.46	1.59	5.0	1.21	1.10

Cable 6: 071681-4C-1

Fiber Identification		CVD Number	Wavelength (nm) 820	850	1060	1100	1200	1300
1	Blue	HG-090261	3.71	3.21	1.42	1.26	1.05	1.32
2	Orange	HG-090202	3.85	3.45	1.72	1.62	1.32	1.54
3	Brown	HG-090240	3.49	3.08	1.36	1.22	1.22	3.46
4	White	HG-090273	3.28	2.82	1.27	1.13	0.91	1.42
5	Slate	HG-090236	3.34	2.94	1.3	1.35	1.16	1.97
6	Green	HG-090189	4.63	4.02	1.86	1.80	1.01	1.82

*Injected NA 0.089.

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Table A-8. Attenuation Versus Wavelength After Cabling (dB/km) (continued).*

Fiber Identification		CVD Number	Wavelength (nm) 820	850	1060	1100	1200	1300
Cable 7: 072081-4C-2								
1	Blue	HG-090375	3.99	3.42	1.57	1.42	1.11	2.62
2	Orange	HG-090385	4.11	3.40	1.62	1.45	1.25	0.77
3	Brown	HG-090300	4.77	4.18	2.17	2.05	1.71	1.37
4	White	HG-090395	4.03	3.34	1.55	1.38	1.16	1.36
5	Slate	HG-090232	4.56	4.11	1.95	1.82	1.50	1.37
6	Green	HG-090197	4.32	3.73	2.03	1.93	1.65	1.28
Cable 8: 082781-4C-1								
1	Blue	HG-090222	3.79	3.31	1.55	1.45	1.42	3.19
2	Orange	HG-100499B	3.39	2.95	1.25	1.12	0.84	0.90
3	Brown	HG-090352	3.84	3.29	1.43	1.31	1.03	1.04
4	White	HG-120079	4.15	3.62	1.92	1.78	1.44	1.32
5	Slate	HG-090399	4.46	3.94	1.88	1.66	1.41	1.51
6	Green	HG-090244	4.43	3.87	2.16	2.00	1.72	1.63

*Injected NA 0.089.

Table A-8. Attenuation Versus Wavelength After Cabling (dB/km) (continued).*

Fiber Identification		CVD Number	Wavelength (nm) 820	850	1060	1100	1200	1300
Cable 9: 102781-4C-1								
1	Blue	HG-120188	3.45	2.95	1.22	0.99	1.03	0.81
2	Orange	HG-090618	4.72	4.29	2.32	2.05	1.91	1.65
3	Brown	HG-090681	3.82	3.34	1.64	1.59	1.43	1.29
4	White	HG-100615	3.87	3.38	1.73	1.55	1.28	1.43
5	Slate	HG-090618	4.55	3.80	2.10	1.94	1.95	1.58
6	Green	HG-090223	4.43	3.98	2.60	2.53	2.51	2.27
Cable 10: 001881-4C-2								
1	Blue	HG-090354	4.27	3.64	2.12	2.01	2.06	2.51
2	Orange	HG-090314	3.87	3.34	1.73	1.61	1.34	1.27
3	Brown	HG-100528	4.81	4.30	2.42	2.25	2.05	2.05
4	White	HG-100528	3.40	2.96	1.21	1.30	1.14	1.31
5	Slate	HG-100528	4.37	4.01	2.64	2.48	2.27	2.28
6	Green	HG-090456	4.20	3.67	1.79	1.58	1.30	1.05

*Injected NA 0.089.

Table A-8. Attenuation Versus Wavelength After Cabling (dB/km) (continued).*

Fiber Identification		CVD Number	Wavelength (nm) 820	850	1060	1100	1200	1300
			Cable 11: 112381-4C-1					
1	Blue	HG-100638	4.30	3.80	2.34	2.18	1.97	1.81
2	Orange	HG-120280	3.91	3.43	1.69	1.53	1.13	0.92
3	Brown	HG-120280	4.00	3.62	1.94	1.84	1.52	1.46
4	White	HG-100638	3.59	3.19	1.53	1.51	1.19	1.23
5	Slate	HG-120280	4.30	3.83	2.14	2.00	1.72	1.63
6	Green	HG-120274	3.74	3.23	1.46	1.34	1.29	1.26
			Cable 12: 091781-4C-1A					
1	Blue	HG-090594	4.62	4.19	2.34	2.19	1.86	1.99
2	Orange	HG-120132	3.47	3.03	1.58	1.46	1.27	1.26
3	Brown	HG-100524	3.45	3.00	1.50	1.39	1.20	1.30
4	White	HG-090328	3.92	3.37	1.70	1.55	1.29	1.37
5	Slate	HG-100529	4.09	3.70	2.16	2.05	1.87	1.99
6	Green	HG-120150	3.28	3.03	1.42	1.26	1.05	0.97

*Injected NA 0.089.

Table A-9. Numerical Aperture (90% Power) After Cabling (Wavelength 820 nm).

Fiber Identification	1		2		3		4		5		6	
1 Blue	HG-090229	0.20	HG-090311	0.23	HG-090192	0.19	HG-090272	0.20	HG-090238	0.21	HG-090261	0.18
2 Orange	HG-090229	0.20	HG-090329	0.20	HG-090240	0.19	HG-090258	0.23	HG-090285	0.21	HG-090202	0.18
3 Brown	HG-090380	0.18	HG-090286	0.20	HG-090418	0.19	HG-090273	0.20	HG-090385	0.20	HG-090240	0.18
4 White	HG-090330	0.20	HG-090286	0.27	HG-090228	0.21	HG-090267	0.19	HG-090287	0.19	HG-090273	0.18
5 Slate	HG-090286	0.20	HG-090266	0.22	HG-090236	0.19	HG-090289	0.20	HG-090386	0.20	HG-090236	0.18
6 Green	HG-090289	0.19	HG-090359	0.20	HG-090311	0.19	HG-090248	0.20	HG-090357	0.20	HG-090189	0.18
	7		8		9		10		11		12	
1 Blue	HG-090375	0.19	HG-090222	0.21	HG-120188	0.25	HG-090354	0.21	HG-100638	0.19	HG-090594	0.18
2 Orange	HG-090385	0.19	HG-1004998	0.20	HG-090618	0.19	HG-090314	0.19	HG-120280	0.18	HG-120132	0.19
3 Brown	HG-090300	0.19	HG-090352	0.20	HG-090681	0.18	HG-100528	0.18	HG-120280	0.19	HG-100524	0.19
4 White	HG-090395	0.20	HG-120079	0.20	HG-100615	0.18	HG-100528	0.18	HG-100638	0.20	HG-090328	0.19
5 Slate	HG-090232	0.21	HG-090394	0.20	HG-090618	0.20	HG-100528	0.18	HG-120280	0.18	HG-100524	0.19
6 Green	HG-090197	0.19	HG-090244	0.19	HG-090223	0.19	HG-090456	0.20	HG-120274	0.17	HG-120150	0.19

APPENDIX B

FUNGUS TESTING RESULTS

AEROSPACE RESEARCH CORPORATION

TEST DATA

CUSTOMER ITT Electro-Optical Division TEST ITEM Fiber Optic Cable

TEST SPECIFICATION MIL-STD-810B, Method 508.1, Procedure I

PARAGRAPH NUMBER PART NUMBER

SERIAL NUMBER 2, 5, 7 and TAOC

TEST TITLE Fungus Test

P.O. NUMBER 34395 TEST CONDUCTED BY Gary W. Long

DATE 8-11-81 TEST TEMP. +84 °F ROOM TEMP. +72 °F BAROMETRIC PRESSURE 29.04 In. Hg.

Prior to start of Fungus Test the Optic Fiber samples were cleaned with isopropyl alcohol. The samples were then placed in the Fungus Chamber and sprayed with previously prepared and tested fungus culture. The fungus culture preparation and test were conducted in accordance with MIL-STD-810B, Method 508.1, Procedure I.

The chamber was maintained at +84°F and 95 percent relative humidity for a period of 28 days. The test was started on August 11, 1981, and was completed on September 8, 1981.

At the end of the 28 day test the samples were visually inspected for fungus growth.

A light fungus growth was observed on all samples.

The Optic Fiber samples were returned to ITT, Electro-Optical Products Division for a complete inspection and test evaluation.

CERTIFICATION

We certify that this test data is a true report on our Fungus Test on four Optic Fiber samples, S/N's 2, 5, 7 and TAOC, submitted by ITT, Electro-Optical Products Division of Roanoke, Virginia. Calibration of our instrumentation is traceable to the National Bureau of Standards.

Respectfully submitted,

AEROSPACE RESEARCH CORPORATION

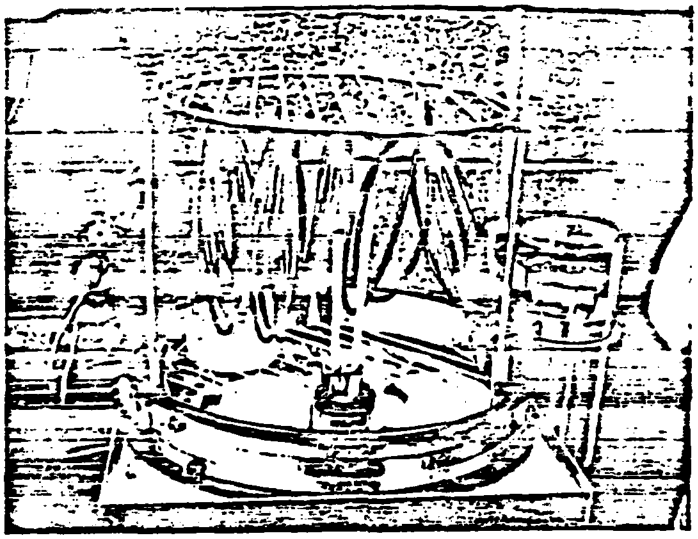
Leslie C. Rose

Leslie C. Rose
Vice President

Subscribed and sworn to before me this 9th day of September, 1981.

Betty C. Fitzpatrick
Notary Public

My commission expires July 16, 1984.



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AEROSPACE RESEARCH CORPORATION

5454 JAE VALLEY RD. — ROANOKE, VIRGINIA 24014 TELEPHONE 342-2961 AREA CODE 703

August 31, 1982

ITT Electro-Optical Products Division
P.O. Box 7065
Roanoke, Virginia 24019

Attention: Mr. Don Taylor

Subject: Verification of fungus growth for tests per MIL-STD-810B

Gentlemen:

Verification of fungus growth on the control item inoculated with the mixed fungus spore suspension is required by method 508 of the subject specification. If after 14 days there is not abundant growth on the control item, the entire test must be repeated. A statement in any of the test reports issued by this company that a fungus test was completed automatically guarantees that abundant growth was observed on the control specimen.

Please do not hesitate to contact us if you have further questions on this.

Very truly yours,

AEROSPACE RESEARCH CORPORATION

Joseph T. Hamrick

Joseph T. Hamrick
President

JTH/jm
cc/L.C.Rose

APPENDIX C

HUMIDITY TEST DATA

Table C-1. Humidity Test Cable Results, Cable 2 and Cable 4.

Fiber Identification		CVD Number	Attenuation (dB/km) at 0.820 nm Before Test	After Test	Δ	Dispersion (ns/km) at 900 nm Before Test	After Test	Δ
Cable 2: 071881-4C-1								
1	Blue	HG-090311	4.56	4.16	-0.40	1.61	0.96	-0.65
2	Orange	HG-090329	4.01	3.80	-0.21	0.75	0.77	+0.02
3	Brown	HG-090286	3.83	3.77	-0.06	0.62	0.69	+0.07
4	White	HG-090286	3.56	3.75	+0.19	0.74	0.94	+0.20
5	Slate	HG-090266	3.58	3.75	+0.17	0.89	1.24	+0.35
6	Green	HG-090359	3.93	3.49	-0.44	0.52	0.50	-0.02
	Average		3.91	3.78	-0.13	0.85	0.85	0.00
Cable 4: 071881-4C-3								
1	Blue	HG-090272	4.22	3.49	-0.73	1.28	1.24	-0.04
2	Orange	HG-090258	4.21	4.31	+0.40	0.40	0.34	-0.06
3	Brown	HG-090273	3.69	3.81	+0.12	0.73	0.68	-0.05
4	White	HG-090267	3.86	3.87	+0.01	1.32	1.37	+0.05
5	Slate	HG-090289	3.92	3.76	-0.16	0.54	0.56	+0.02
6	Green	HG-090248	3.91	4.46	+0.55	0.56	0.64	+0.08
	Average		3.97	3.95	-0.02	0.80	0.80	0.00

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Table C-2. Humidity Test Cable Results, Cable 6 and Cable 7.

	Fiber Identification	CVD Number	Attenuation (dB/km) at 820 nm			Dispersion (ns/km) at 900 nm		
			Before Test	After Test	Δ	Before Test	After Test	Δ
	Cable 6: 071681-4C-1							
1	Blue	HG-090261	4.25	3.88	-0.37	0.69	0.80	+0.11
2	Orange	HG-090202	3.76	3.96	+0.20	0.63	0.71	+0.08
3	Brown	HG-090240	3.93	3.96	+0.03	0.49	0.56	+0.07
4	White	HG-090273	3.61	4.02	+0.03	0.59	0.65	+0.06
5	Slate	HG-090236	3.72	3.89	+0.17	0.69	0.75	+0.06
6	Green	HG-090189	4.51	4.66	+0.15	0.55	0.78	+0.23
	Average		3.96	4.06	+0.10	0.61	0.71	+0.10
	Cable 7: 072081-4C-2							
1	Blue	HG-090375	4.02	3.72	-0.30	0.97	0.87	-0.10
2	Orange	HG-090385	4.04	3.93	-0.11	1.48	1.02	-0.46
3	Brown	HG-090300	4.69	3.96	-0.73	0.43	0.34	-0.09
4	White	HG-090395	4.27	3.90	-0.32	1.21	1.09	-0.12
5	Slate	HG-090232	4.90	4.88	-0.02	0.64	0.58	-0.06
6	Green	HG-090197	4.01	4.74	+0.73	0.61	0.49	-0.12
	Average		4.31	4.19	-0.12	0.89	0.73	-0.16

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Table C-3. Attenuation Versus Wavelength* (dB/km) After Humidity.

Cable 2: 071881-4C-1

Fiber Identification	CVD Number	Wavelength (nm) 820	850	1060	1100	1200	1300
1 Blue	HG-090311	4.16	3.70	1.71	1.51	1.17	1.05
2 Orange	HG-090329	3.80	3.30	1.51	1.36	1.16	1.33
3 Brown	HG-090286	3.77	3.33	1.73	1.61	1.38	1.42
4 White	HG-090286	3.75	3.16	1.52	1.47	1.20	1.20
5 Slate	HG-090266	3.75	2.12	1.42	1.18	1.10	1.19
6 Green	HG-090359	3.49	3.08	1.46	1.30	1.11	1.13

Cable 4: 071881-4C-3

Fiber Identification	CVD Number	820	850	1060	1100	1200	1300
1 Blue	HG-090272	3.49	3.06	1.37	1.35	1.20	1.36
2 Orange	HG-090258	4.31	3.79	1.92	1.77	1.53	1.56
3 Brown	HG-090273	3.81	3.34	1.57	1.34	1.07	1.06
4 White	HG-090267	3.87	3.37	1.70	1.59	1.47	1.50
5 Slate	HG-090289	3.76	3.36	1.66	1.56	1.29	1.30
6 Green	HG-090248	4.46	3.92	2.20	2.04	1.80	1.81

*Injected NA 0.089.

21708a

Table C-3. Attenuation Versus Wavelength* (dB/km) After Humidity (continued).

Fiber Identification	CVD Number	Wavelength (nm) 820	850	1060	1100	1200	1300
Cable 6: 071681-4C-1							
1 Blue	HG-090261	3.88	3.35	1.49	1.34	1.16	1.20
2 Orange	HG-090202	3.96	3.49	1.78	1.61	1.37	1.32
3 Brown	HG-090240	3.96	3.57	1.71	1.62	1.69	3.58
4 White	HG-090273	4.02	3.52	1.73	1.58	1.30	1.35
5 Slate	HG-090236	3.89	3.39	1.59	1.46	1.20	1.27
6 Green	HG-090189	4.66	3.98	1.87	1.65	1.37	1.22
Cable 7: 072081-4C-2							
1 Blue	HG-090375	3.72	3.22	1.55	1.38	1.14	1.12
2 Orange	HG-090385	3.93	3.43	1.62	1.46	0.62	0.59
3 Brown	HG-090300	3.96	3.50	1.66	1.63	1.52	1.75
4 White	HG-090395	3.90	3.31	1.41	1.47	1.15	1.55
5 Slate	HG-090232	4.88	4.33	2.20	1.99	1.72	1.71
6 Green	HG-090197	4.74	4.21	2.41	2.26	2.09	2.02

*Injected NA 0.089.

Table C-4. Attenuation Versus Injected NA After Humidity Test (Wavelength 820 nm).

Fiber Identification	CVD Number	Injection NA 0.089	0.0124	0.0176	0.243
Cable 2: 071881-4C-1					
1 Blue	HG-090311	4.16	3.84	2.70	3.36
2 Orange	HG-090329	3.80	2.79	3.73	3.82
3 Brown	HG-090286	3.77	3.77	3.44	3.40
4 White	HG-090286	3.75	3.52	2.61	3.03
5 Slate	HG-090266	3.75	3.56	3.60	2.49
6 Green	HG-090359	3.49	3.32	2.61	2.42
Cable 4: 071881-4C-3					
1 Blue	HG-090272	3.49	3.51	3.57	3.57
2 Orange	HG-090258	4.31	4.36	4.23	4.30
3 Brown	HG-090273	3.81	3.99	4.06	4.08
4 White	HG-090267	3.87	3.65	3.25	3.27
5 Slate	HG-090289	3.76	3.75	4.04	4.13
6 Green	HG-090248	4.46	4.43	4.49	4.81

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Table C-4. Attenuation Versus Injected NA After Humidity Test (Wavelength 820 nm) (continued).

Fiber Identification	CVD Number	Injection NA 0.089	0.0124	0.0176	0.243
Cable 6: 071681-4C-1					
1 Blue	HG-090261	3.88	3.98	3.85	4.01
2 Orange	HG-090202	3.96	3.97	4.08	4.26
3 Brown	HG-090240	3.96	3.74	4.10	4.15
4 White	HG-090273	4.02	4.01	4.30	4.29
5 Slate	HG-090236	3.89	3.90	4.00	4.06
6 Green	HG-090189	4.66	4.70	4.61	4.83
Cable 7: 072081-4C-2					
1 Blue	HG-090375	3.72	3.92	4.00	4.23
2 Orange	HG-090385	3.93	3.86	3.98	4.24
3 Brown	HG-090300	3.96	3.84	3.43	4.09
4 White	HG-090395	3.90	4.04	3.93	3.91
5 Slate	HG-090232	4.88	4.80	4.86	4.87
6 Green	HG-090197	4.74	4.92	5.02	5.03

Table C-5. Numerical Aperture (90% Power) After Humidity Test (Wavelength 820 nm).

Fiber Identification		2		4		6		7	
1	Blue	HG-090311	0.21	HG-090272	0.20	HG-090261	0.20	HG-090379	0.18
2	Orange	HG-090329	0.19	HG-090258	0.19	HG-090202	0.23	HG-090385	0.19
3	Brown	HG-090286	0.18	HG-090273	0.20	HG-090240	0.20	HG-090300	0.20
4	White	HG-090286	0.19	HG-090267	0.19	HG-090273	0.19	HG-090395	0.20
5	Slate	HG-090266	0.18	HG-090289	0.20	HG-090236	0.21	HG-090232	0.20
6	Green	HG-090359	0.21	HG-090248	0.20	HG-090189	0.20	HG-090197	0.20

APPENDIX D

VIBRATION TEST DATA

Table D-1. Vibration Test Cable Results, Cable 2 and Cable 6.

Fiber Identification	CVD Number	Attenuation (dB/km) at 820 nm Before Test	Attenuation After Test	Attenuation Δ	Dispersion (ns/km) at 900 nm Before Test	Dispersion After Test	Dispersion Δ
Cable 2: 071881-4C-1							
1 Blue	HG-090311	4.16	4.14	-0.02	0.96	1.61	+0.65
2 Orange	HG-090329	3.80	3.98	+0.18	0.77	0.75	-0.02
3 Brown	HG-090286	3.77	3.52	-0.25	0.69	0.62	-0.07
4 White	HG-090286	3.75	3.40	-0.35	0.94	0.74	-0.20
5 Slate	HG-090266	3.75	3.42	-0.33	1.24	0.89	-0.35
6 Green	HG-090359	3.49	3.49	+0.00	0.50	0.52	+0.02
Average		3.78	3.65	-0.13	0.85	0.85	0.00
Cable 6: 071681-4C-1							
1 Blue	HG-090261	3.88	3.40	-0.48	0.80	0.80	0.00
2 Orange	HG-090202	3.96	3.89	-0.07	0.71	0.82	+0.11
3 Brown	HG-090240	3.96	3.83	-0.13	0.56	0.50	-0.06
4 White	HG-090273	4.02	2.96	-1.06	0.65	0.62	-0.03
5 Slate	HG-090236	3.89	3.63	-0.26	0.75	0.66	-0.09
6 Green	HG-090189	4.66	4.12	-0.54	0.78	0.62	-0.16
Average		4.06	3.63	-0.43	0.71	0.67	-0.04

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Table D-1. Vibration Test Cable Results, Cable 2 and Cable 6 (continued).

Cable 7: 072081-4C-2

Fiber Identification		CVD Number	Attenuation (dB/km) at 820 nm Before Test	After Test	Δ	Dispersion (ns/km) at 900 nm Before Test	After Test	Δ
1	Blue	HG-090375	3.72	4.04	+0.32	0.97	0.79	-0.18
2	Orange	HG-090385	3.93	3.07	-0.86	1.48	1.15	-0.33
3	Brown	HG-090306	3.96	4.93	+0.97	0.43	0.35	+0.08
4	White	HG-090395	3.90	3.50	-0.40	1.21	1.37	+0.16
5	Slate	HG-090232	4.88	4.59	-0.29	0.64	0.54	-0.10
6	Green	HG-090197	4.74	4.37	-0.37	0.61	0.56	-0.05
	Average		4.18	4.08	-0.10	0.89	0.79	-0.10

Cable 8: 082781-4C-1

Fiber Identification		CVD Number	Attenuation Before Test	After Test	Δ	Dispersion Before Test	After Test	Δ
1	Blue	HG-090222	4.66	3.92	-0.74	1.80	1.58	-0.22
2	Orange	HG-100499B	3.35	3.37	+0.02	0.75	0.75	0.00
3	Brown	HG-090352	3.77	3.57	-0.20	0.48	0.50	+0.02
4	White	HG-120079	3.71	3.89	+0.18	1.22	1.28	+0.06
5	Slate	HG-090394	4.01	4.50	+0.49	0.86	0.88	+0.02
6	Green	HG-090244	4.06	4.74	+0.68	0.74	0.75	+0.01
	Average		3.92	3.99	+0.07	0.97	0.95	-0.02

Table D-2. Attenuation Versus Wavelength* (dB/km) After Vibration.

Fiber Identification		CVD Number	Wavelength (nm) 820	850	1060	1100	1200	1300
				Cable 2				
1	Blue	HG-090375	4.14	3.56	1.58	1.40	1.12	1.01
2	Orange	HG-090385	3.98	3.59	1.77	1.63	1.39	1.41
3	Brown	HG-090300	3.52	3.08	1.50	1.34	1.15	1.18
4	White	HG-090395	3.40	2.95	1.43	1.24	1.03	1.08
5	Slate	HG-090232	3.42	2.92	1.10	1.14	1.02	1.31
6	Green	HG-090197	3.49	3.17	1.44	1.37	1.02	1.09
				Cable 6: 071681-4C-1				
1	Blue	HG-090261	3.40	2.27	1.13	1.33	1.26	1.69
2	Orange	HG-090202	3.89	3.78	1.94	1.64	1.39	1.35
3	Brown	HG-090240	3.83	3.40	1.69	1.58	1.62	2.48
4	White	HG-090273	2.96	2.26	1.26	1.00	0.73	0.80
5	Slate	HG-090236	3.63	3.12	1.53	1.39	1.18	1.23
6	Green	HG-090189	4.12	3.56	1.63	1.48	1.21	1.16

*Injected NA 0.089.

Table D-2. Attenuation Versus Wavelength* (dB/km) After Vibration (continued).

Fiber Identification	CVD Number	Wavelength (nm) 820	850	1060	1100	1200	1300
Cable 7: 072081-4C-2							
1 Blue	HG-090375	4.04	3.50	1.71	1.50	1.21	1.23
2 Orange	HG-090385	3.07	2.92	1.63	1.67	1.69	1.87
3 Brown	HG-090300	4.93	4.46	2.46	2.27	1.97	1.97
4 White	HG-090395	3.50	3.03	1.32	1.23	1.02	1.33
5 Slate	HG-090232	4.59	4.12	2.07	1.88	1.49	1.59
6 Green	HG-090197	4.37	3.84	2.17	2.05	1.75	1.74
Cable 8: 082781-4C-1							
1 Blue	HG-090222	3.92	3.36	1.62	1.45	1.44	3.17
2 Orange	HG-100499B	3.37	2.97	1.33	1.22	0.99	1.07
3 Brown	HG-090352	3.57	3.20	1.45	1.28	1.07	1.22
4 White	HG-120079	3.89	3.44	1.69	1.62	1.29	1.24
5 Slate	HG-090394	4.50	4.42	2.04	1.78	1.38	1.27
6 Green	HG-090244	4.74	4.24	2.48	2.38	2.17	2.07

*Injected NA 0.089.

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Table D-3. Attenuation Versus Injected NA After Vibration (Wavelength 820 nm).

Cable 2: 071881-4C-1

Fiber Identification		CVD Number	Injection NA 0.089	0.0124	0.0176	0.243
1	Blue	HG-090311	4.14	4.16	4.22	4.36
2	Orange	HG-090329	3.98	4.01	4.19	4.44
3	Brown	HG-090286	3.52	3.67	3.69	3.65
4	White	HG-090286	3.40	3.36	3.67	3.76
5	Slate	HG-090266	3.42	3.50	3.63	3.80
6	Green	HG-090359	3.61	3.48	3.58	3.71

Cable 6: 071681-4C-1

Fiber Identification		CVD Number	Injection NA 0.089	0.0124	0.0176	0.243
1	Blue	HG-090261	3.40	3.40	3.54	3.65
2	Orange	HG-090202	3.89	3.96	3.86	4.10
3	Brown	HG-090240	3.83	3.89	4.01	4.07
4	White	HG-090273	2.96	2.42	2.26	2.27
5	Slate	HG-090236	3.63	3.63	3.64	3.93
6	Green	HG-090189	4.12	3.97	4.01	4.18

Table D-3. Attenuation Versus Injected NA After Vibration (Wavelength 820 nm) (continued).

Cable 7: 072081-4C-2

Fiber Identification		CVD Number	Injection NA 0.089	0.0124	0.0176	0.243
1	Blue	HG-090375	4.04	4.14	4.46	4.48
2	Orange	HG-090385	3.07	4.70	4.08	3.82
3	Brown	HG-090300	4.93	4.95	4.88	5.27
4	White	HG-090395	3.50	3.34	3.58	3.78
5	Slate	HG-090232	4.59	4.28	4.31	4.45
6	Green	HG-090197	4.37	4.55	4.61	4.72

Cable 8: 082781-4C-1

Fiber Identification		CVD Number	Injection NA 0.089	0.0124	0.0176	0.243
1	Blue	HG-090222	3.92	3.69	3.90	3.89
2	Orange	HG-100499B	3.37	3.54	3.64	3.63
3	Brown	HG-090352	3.57	3.61	3.85	3.91
4	White	HG-120079	3.89	3.88	3.85	3.39
5	Slate	HG-090397	4.50	4.57	3.91	3.77
6	Green	HG-090244	4.74	4.67	4.97	5.04

Table D-4. Numerical Aperture (90% Power) After Vibration (Wavelength 820 nm.)

Fiber Identification		2		6		7		8	
1	Blue	HG-090311	0.18	HG-090261	0.19	HG-090375	0.18	HG-090222	0.19
2	Orange	HG-090329	0.19	HG-090202	0.19	HG-090385	0.18	HG-100499B	0.18
3	Brown	HG-090286	0.19	HG-090240	0.19	HG-090300	0.20	HG-090352	0.19
4	White	HG-090286	0.19	HG-090273	0.19	HG-090395	0.20	HG-120079	0.19
5	Slate	HG-090266	0.19	HG-090236	0.20	HG-090232	0.19	HG-090394	0.18
6	Green	HG-090359	0.18	HG-090189	0.19	HG-090197	0.19	HG-090244	0.23

AEROSPACE RESEARCH CORPORATION

TEST DATA

CUSTOMER ITT, Electro-Optical Products TEST ITEM Fiber Optic Cable (1 reel)

TEST SPECIFICATION Doc. Id. No. 80-29-09, Revision II

PARAGRAPH NUMBER 4.6 PART NUMBER

SERIAL NUMBER # 2

TEST TITLE Vibration Test (Loose Cargo)

P.O. NUMBER 34394-01 TEST CONDUCTED BY Gary W. Long

DATE 9-26-81 TEST TEMP. +70 °F ROOM TEMP. +70 °F BAROMETRIC PRESSURE 29.20 In. Hg.

The Loose Cargo Vibration Test was conducted in accordance with paragraph 4.6 of Preproduction Test Procedure for Ruggedized Tactical Fiber Optic Cable Document Identification number 80-29-09, Revision II.

The test sample was placed in the test fixture with reel axis perpendicular to test bed of package tester. The package tester operated at 284 r.p.m., with 1 inch vertical double displacement. The sample was vibrated for 30 minutes.

The reel was then turned 180 degrees and tested for 30 minutes.

The reel was then placed in the axis parallel to the test bed and tested for 30 minutes. After 30 minutes vibration the reel was turned 180 degrees and vibrated for 30 minutes.

At the conclusion of the 2 hour vibration test the sample was inspected for evidence of visible physical damage and none was observed.

Remarks: The reel of Fiber Optic Cable was returned to ITT for complete inspection and test evaluation.

AEROSPACE RESEARCH CORPORATION

TEST DATA

CUSTOMER ITT, Electro-Optical Products TEST ITEM Fiber Optic Cable (1 reel)

TEST SPECIFICATION Doc. Id No. 80-29-09, Revision II

PARAGRAPH NUMBER 4.6 PART NUMBER

SERIAL NUMBER # 2

TEST TITLE Vibration Test (Secured Cargo)

P.O. NUMBER 34395-01 TEST CONDUCTED BY S.D. Bernard

DATE 9-25-81 TEST TEMP. +78 °F ROOM TEMP. +78 °F BAROMETRIC PRESSURE 29.33 In. Hg.

The Secured Cargo Vibration Test was conducted in accordance with Preproduction Test Procedure for Ruggedized Tactical Fiber Optic Cable Document Identification number 80-29-09, Revision II.

The test sample was mounted on the vibration exciter and subjected to the following secured cargo vibration test in the lateral and longitudinal axes. The vibration time was 84 minutes per axis. The sweep time from 6 to 200 to 6 Hz was 12 minutes.

Frequency, Hz	G level
6 - 200	1.5

At the conclusion of the vibration test the sample was inspected for evidence of visible physical damage and none was observed.

CERTIFICATION

We certify that this test data is a true report of our Vibration Tests (Secured Cargo, and Loose Cargo) on one reel of Fiber Optic Cable, submitted by ITT, Electro-Optical Products Division, Roanoke, Virginia. Calibration of our instrumentation is traceable to the National Bureau of Standards.

Respectfully submitted,

AEROSPACE RESEARCH CORPORATION

Leslie C. Rose

Leslie C. Rose
Vice President

Subscribed and sworn to before me this 29th day of September, 1981.

Betty C. Fitzpatrick
Notary Public

My commission expires July 16, 1984.

AEROSPACE RESEARCH CORPORATION

TEST DATA

CUSTOMER ITT, Electro-Optical Products TEST ITEM Fiber Optic Cable (1 reel)

TEST SPECIFICATION Doc. Id No. 80-29-09, Revision II

PARAGRAPH NUMBER 4.6 PART NUMBER

SERIAL NUMBER #6 and #7

TEST TITLE Vibration Test (Secured Cargo)

P.O. NUMBER 34395-01 TEST CONDUCTED BY Henry Messenger

DATE 9-21-81 TEST TEMP. +70 °F ROOM TEMP. +70 °F BAROMETRIC PRESSURE 29.03 In. Hg.

The Secured Cargo Vibration Test was conducted in accordance with Preproduction Test Procedure for Ruggedized Tactical Fiber Optic Cable Document Identification number 80-29-09, Revision II.

The test sample was mounted on the vibration exciter and subjected to the following secured cargo vibration test in the lateral and longitudinal axes. The vibration time was 84 minutes per axis. The sweep time from 6 to 200 to 6 Hz was 12 minutes.

Frequency, Hz	G level
6 - 200	1.5

At the conclusion of the vibration test the sample was inspected for evidence of visible physical damage and none was observed.

AEROSPACE RESEARCH CORPORATION

TEST DATA

CUSTOMER ITT, Electro-Optical Products TEST ITEM Fiber Optic Cable (1 reel)

TEST SPECIFICATION Doc. Id. No. 80-29-09, Revision II

PARAGRAPH NUMBER 4.6 PART NUMBER

SERIAL NUMBER #6 and #7

TEST TITLE Vibration Test (Loose Cargo)

P.O. NUMBER 34395-01 TEST CONDUCTED BY Gary W. Long

DATE 9-22-81 TEST TEMP. +70 °F ROOM TEMP. +70 °F BAROMETRIC PRESSURE 29.00 In. Hg.

The Loose Cargo Vibration Test was conducted in accordance with paragraph 4.6 of Preproduction Test Procedure for Ruggedized Tactical Fiber Optic Cable Document Identification number 80-29-09, Revision II.

The test sample was placed in the test fixture with reel axis perpendicular to test bed of package tester. The package tester operated at 284 r.p.m., with 1 inch vertical double displacement. The sample was vibrated for 30 minutes.

The reel was then turned 180 degrees and tested for 30 minutes.

The reel was then placed in the axis parallel to the test bed and tested for 30 minutes. After 30 minutes vibration the reel was turned 180 degrees and vibrated for 30 minutes.

At the conclusion of the 2 hour vibration test the sample was inspected for evidence of visible physical damage and none was observed.

Remarks: The reel of Fiber Optic Cable was returned to ITT for complete inspection and test evaluation.

CERTIFICATION

We certify that this test data is a true report of our Vibration Tests (Secured Cargo and Loose Cargo) on two reels of Fiber Optic Cable, S/N's 6 and 7, submitted by ITT, Electro-Optical Products Division, Roanoke, Va. Calibration of our instrumentation is traceable to the National Bureau of Standards.

Respectfully submitted,

AEROSPACE RESEARCH CORPORATION

Leslie C. Rose

Leslie C. Rose
Vice President

Subscribed and sworn to before me this 22nd day of September, 1981.

Betty C. Fitzpatrick
Notary Public

My commission expires July 16, 1984.

AEROSPACE RESEARCH CORPORATION

TEST DATA

CUSTOMER ITT, Electro-Optical Products TEST ITEM Fiber Optic Cable (l reel)

TEST SPECIFICATION Doc. Id. No. 80-29-09, Revision II

PARAGRAPH NUMBER 4.6 PART NUMBER

SERIAL NUMBER #8

TEST TITLE Vibration Test (Loose Cargo)

P.O. NUMBER 34395 TEST CONDUCTED BY Gary W. Long

DATE 9-17-81 TEST TEMP. +75 °F ROOM TEMP. +75 °F BAROMETRIC PRESSURE 29.03 In. Hg.

The Loose Cargo Vibration Test was conducted in accordance with paragraph 4.6 of Preproduction Test Procedure for Ruggedized Tactical Fiber Optic Cable Document Identification number 80-29-09, Revision II.

The test sample was placed in the test fixture with reel axis perpendicular to test bed of package tester. The package tester operated at 284 r.p.m., with 1 inch vertical double displacement. The sample was vibrated for 30 minutes.

The reel was then turned 180 degrees and tested for 30 minutes.

The reel was then placed in the axis parallel to the test bed and tested for 30 minutes. After 30 minutes vibration the reel was turned 180 degrees and vibrated for 30 minutes.

At the conclusion of the 2 hour vibration test the sample was inspected for evidence of visible physical damage and none was observed.

Remarks: The reel of Fiber Optic Cable was returned to ITT for complete inspection and test evaluation.

AEROSPACE RESEARCH CORPORATION
TEST DATA

CUSTOMER ITT, Electro-Optical Products TEST ITEM Fiber Optic Cable (1 reel)

TEST SPECIFICATION Doc. Id No. 80-29-09, Revision II

PARAGRAPH NUMBER 4.6 PART NUMBER

SERIAL NUMBER #8

TEST TITLE Vibration Test (Secured Cargo)

P.O. NUMBER 34395 TEST CONDUCTED BY S.D. Bernard

DATE 9-16-81 TEST TEMP. +79 °F ROOM TEMP. +79 °F BAROMETRIC PRESSURE 28.93 In. Hg.

The Secured Cargo Vibration Test was conducted in accordance with Preproduction Test Procedure for Ruggedized Tactical Fiber Optic Cable Document Identification number 80-29-09, Revision II.

The test sample was mounted on the vibration exciter and subjected to the following secured cargo vibration test in the lateral and longitudinal axes. The vibration time was 84 minutes per axis. The sweep time from 6 to 200 to 6 Hz was 12 minutes.

Frequency, Hz	G level
6 - 200	1.5

At the conclusion of the vibration test the sample was inspected for evidence of visible physical damage and none was observed.

CERTIFICATION

We certify that this test data is a true report on our Vibration Tests (Secured Cargo, and Loose Cargo) on one reel Fiber Optic Cable, submitted by ITT, Electro-Optical Products Division, Roanoke, Virginia. Calibration of our instrumentation is traceable to the National Bureau of Standards.

Respectfully submitted,

AEROSPACE RESEARCH CORPORATION

Leslie C. Rose
Vice President

Subscribed and sworn to before me this 18th day of September, 1981.

Betty C. Fitzpatrick
Notary Public

My commission expires July 16, 1984.

APPENDIX E

TEMPERATURE SHOCK TEST DATA

Table E-1. Temperature Shock Test Cable Results, Cable 2 and Cable 5.

Fiber Identification		CVD Number	Attenuation (dB/km) at 820 nm Before Test	Attenuation (dB/km) at 820 nm After Test	Attenuation (dB/km) at 820 nm Δ	Dispersion (ns/km) at 900 nm Before Test	Dispersion (ns/km) at 900 nm After Test	Dispersion (ns/km) at 900 nm Δ
Cable 2: 071881-4C-1								
1	Blue	HG-090311	4.21	4.56	+0.35	1.08	1.05	-0.03
2	Orange	HG-090329	3.90	4.01	+0.11	0.80	0.96	+0.16
3	Brown	HG-090286	3.57	3.83	+0.26	0.78	0.75	-0.03
4	White	HG-090286	3.40	3.56	+0.16	1.01	1.07	+0.06
5	Slate	HG-090266	3.49	3.58	+0.09	1.20	1.29	+0.09
6	Green	HG-090359	3.75	3.93	+0.18	0.63	0.54	-0.09
	Average		3.72	3.91	+0.19	0.91	0.94	+0.03
Cable 5: 072081-4C-1								
1	Blue	HG-090238	4.64	3.73	-0.91	0.11	0.96	+0.85
2	Orange	HG-090285	4.02	3.84	-0.18	1.21	1.29	+0.08
3	Brown	HG-090385	3.24	3.75	+0.51	1.52	1.12	-0.40
4	White	HG-090287	3.86	3.81	-0.05	0.92	0.91	-0.01
5	Slate	HG-090386	4.05	4.03	-0.02	1.24	1.35	+0.11
6	Green	HG-090357	3.85	4.66	+0.81	0.52	0.64	+0.12
	Average		3.94	3.97	+0.03	0.92	1.04	+0.12

21708a

Table E-2. Temperature Shock Test Cable Results, Cable 6 and Cable 7.

Fiber Identification		CVD Number	Attenuation (dB/km) at 820 nm Before Test	After Test	Δ	Dispersion (ns/km) at 900 nm Before Test	After Test	Δ
Cable 6: 071681-4C-1								
1	Blue	HG-090261	3.90	4.25	+0.35	0.76	0.69	-0.06
2	Orange	HG-090202	3.78	3.76	-0.02	0.73	0.63	-0.10
3	Brown	HG-090240	3.95	3.93	-0.02	0.52	0.49	-0.03
4	White	HG-090273	4.59	3.61	-0.98	0.66	0.59	-0.07
5	Slate	HG-090236	3.59	3.72	+0.13	0.71	0.69	-0.02
6	Green	HG-090189	4.61	4.51	-0.10	0.74	0.55	-0.19
	Average		4.07	3.96	-0.11	0.69	0.61	-0.08
Cable 7: 072081-4C-2								
1	Blue	HG-090375	3.95	4.02	-0.07	0.97	0.97	0.00
2	Orange	HG-090385	4.07	4.04	-0.03	1.26	1.48	+0.22
3	Brown	HG-090300	4.71	4.69	-0.02	0.44	0.43	-0.01
4	White	HG-090395	3.85	4.22	+0.37	1.22	1.21	-0.01
5	Slate	HG-090232	4.71	4.90	+0.19	1.02	0.64	-0.38
6	Green	HG-090197	4.14	4.01	-0.13	0.65	0.61	-0.04
	Average		4.23	4.31	+0.08	0.93	0.89	-0.04

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Table E-3. Attenuation Versus Wavelength* (dB/km) After Temperature Shock Test.

Cable 2: 071881-4C-1

	Fiber	CVD Number	Wavelength (nm) 820	850	1060	1100	1200	1300
1	Blue	HG-090311	4.56	3.98	1.95	1.77	1.50	1.43
2	Orange	HG-090329	4.01	3.58	1.76	1.64	1.38	1.49
3	Brown	HG-090286	3.83	3.30	1.70	1.59	1.39	1.38
4	White	HG-090286	3.56	3.09	1.43	1.37	1.17	1.20
5	Slate	HG-090266	3.58	3.33	1.56	1.40	1.13	1.36
6	Green	HG-090359	3.93	3.54	1.8	1.63	1.35	1.36

Cable 5: 072081-4C-1

	Fiber	CVD Number	820	850	1060	1100	1200	1300
1	Blue	HG-090238	3.73	3.31	1.51	1.37	1.09	1.20
2	Orange	HG-090285	3.84	3.37	1.65	1.62	1.40	1.47
3	Brown	HG-090385	3.75	3.32	1.74	1.60	1.48	1.42
4	White	HG-090287	3.81	3.37	1.53	1.38	1.12	1.03
5	Slate	HG-090386	4.03	3.45	1.52	1.32	1.07	1.03
6	Green	HG-090357	4.66	4.21	2.68	2.59	2.50	2.60

*Injected NA 0.089.

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Table E-3. Attenuation Versus Wavelength* (dB/km) After Temperature Shock Test (continued).

Cable 6: 071681-4C-1

	Fiber	CVD Number	820	850	1060	1100	1200	1300
			Wavelength (nm)					
1	Blue	HG-090261	4.05	3.50	1.65	1.52	1.28	1.42
2	Orange	HG-090202	3.76	3.30	1.82	1.65	1.20	1.25
3	Brown	HG-090240	3.93	3.57	1.91	1.82	1.84	3.51
4	White	HG-090273	3.61	3.21	1.49	1.32	1.07	1.13
5	Slate	HG-090236	3.72	3.21	1.51	1.38	1.15	1.24
6	Green	HG-090189	4.51	3.87	2.98	1.65	1.35	1.25

Cable 7: 072081-4C-2

	Fiber	CVD Number	820	850	1060	1100	1200	1300
1	Blue	HG-090375	4.02	3.46	1.60	1.46	1.21	1.20
2	Orange	HG-090385	4.04	3.49	1.67	1.46	1.22	1.14
3	Brown	HG-090300	4.69	4.20	2.19	2.05	1.75	4.64
4	White	HG-090395	4.22	3.67	1.75	1.64	1.38	1.68
5	Slate	HG-090232	4.90	4.40	2.29	2.11	1.77	1.79
6	Green	HG-090197	4.01	3.57	1.83	1.75	1.49	1.48

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*Injected NA 0.089.

Table E-4. Attenuation Versus Injected NA After Temperature Shock (Wavelength 820 nm).

Cable 2: 071881-4C-1

	Fiber	CVD Number	Injection NA 0.089	0.124	0.176	0.243
1	Blue	HG-090311	4.56	4.74	4.52	4.74
2	Orange	HG-090329	4.01	3.97	4.16	4.30
3	Brown	HG-090286	3.83	3.79	3.83	3.84
4	White	HG-090286	3.56	3.56	3.84	3.88
5	Slate	HG-090266	3.58	3.68	3.97	3.82
6	Green	HG-090359	3.93	4.41	4.21	4.33

Cable 5: 072081-4C-1

	Fiber	CVD Number	Injection NA 0.089	0.124	0.176	0.243
1	Blue	HG-090238	3.73	3.74	4.02	4.11
2	Orange	HG-090285	3.84	3.62	3.69	3.97
3	Brown	HG-090385	3.75	3.57	3.81	3.70
4	White	HG-090287	3.81	3.94	4.15	4.29
5	Slate	HG-090386	4.03	3.94	4.27	4.28
6	Green	HG-090357	4.66	4.65	4.86	5.24

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Table E-4. Attenuation Versus Injected NA After Temperature Shock (Wavelength 820 nm) (continued).

Cable 6: 071681-4C-1

	Fiber	CVD Number	Injection NA 0.089	0.124	0.176	0.243
1	Blue	HG-090261	4.05	4.00	4.26	4.13
2	Orange	HG-090202	3.76	3.69	3.90	4.00
3	Brown	HG-090240	3.93	4.01	4.06	4.03
4	White	HG-090273	3.61	4.22	3.82	4.00
5	Slate	HG-090236	3.72	3.75	3.83	3.90
6	Green	HG-090189	4.51	4.39	4.63	4.62

Cable 7: 072081-4C-2

	Fiber	CVD Number	Injection NA 0.089	0.124	0.176	0.243
1	Blue	HG-090222	4.02	4.20	4.27	4.35
2	Orange	HG-100999B	4.04	4.20	4.10	4.20
3	Brown	HG-090352	4.69	4.86	4.66	4.71
4	White	HG-120079	4.22	4.25	4.37	4.55
5	Slate	HG-090394	4.90	4.79	4.76	4.90
6	Green	HG-090244	4.01	4.18	4.21	4.40

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Table E-5. Numerical Aperture (90% Power) After Temperature Shock (Wavelength 820 nm).

		Cable Number							
	Fiber	2		5		6		7	
1	Blue	HG-090311	0.21	HG-090238	0.20	HG-090261	0.25	HG-090375	0.22
2	Orange	HG-090329	0.24	HG-090285	0.21	HG-090202	0.24	HG-090385	0.22
3	Brown	HG-090286	0.23	HG-090385	0.20	HG-090240	0.21	HG-090300	0.25
4	White	HG-090286	0.25	HG-090287	0.22	HG-090273	0.23	HG-090395	0.21
5	Slate	HG-090266	0.23	HG-090386	0.22	HG-090236	0.22	HG-090232	0.21
5	Green	HG-090359	0.23	HG-090357	0.20	HG-090189	0.21	HG-090197	0.24

APPENDIX F

FINISHED CABLE TEST DATA

Table F-1. Finished Cable Test Results, MM&T Cables (Confirmatory).

CABLE	IMPACT TEST 3-FT-LB													
	ROOM TEMPERATURE					+71C					-55C			
	S	BF	%SF	JS		S	BF	%SF	JS		S	BF	%SF	JS
3# 071881-4C-2	6	0	100	0		6	0	100	0		6	6	83	0
5# 072081-4C-1	6	0	100	0		6	0	100	0		6	6	83	0
7# 072081-4C-2	6	0	100	0		6	0	100	0		6	5	86	0
					BEND	TEST		LOAD	MASS =	10 KG	BEND	RADIUS	= 1.27	CM
3# 071881-4C-2	6	0	100	0		6	0	100	0		6	0	100	0
5# 072081-4C-1	6	0	100	0		6	0	100	0		6	0	100	0
7# 072081-4C-2	6	0	100	0		6	0	100	0		6	0	100	0
					TWIST	TEST		LOAD	MASS = 10	KG	PULLEY	CENTER	DIA =	3.175CM
3# 071881-4C-2	6	0	100	0		6	0	100	0		6	0	100	0
5# 072081-4C-1	6	0	100	0		6	0	100	0		6	0	100	0
7# 072081-4C-2	6	0	100	0		6	0	100	0		6	0	100	0

WHERE: S = NO OF SAMPLE TESTED
BF = NO OF BROKEN FIBERS

% SF = PERCENT OF SURVIVING FIBERS = $\frac{S \times 6 - BF}{S \times 6} \times 100$

JS = JAKET SPLIT

II-3.1 TENSILE LOAD

Cable 071881-4C-1 #3

Sample Length ____________ m

Gage Length 6 m

Starting Tensile Load(t=0)	410	lb_f	400 min
($1\ lb_f = 4.448$ N)	1823	N	1780 min

Specification

Adjustments During Test

Approximate Time s	Initial Load lb_f	Adjusted Load lb_f
15	380	400
*45	395	410

Finished Tensile Load (t=60s) 410 lb_f
Post Test Continuity 1823 N

Number of Continuous Fibers	Specification
6	6

Remarks: *Adjusted prematurely

Observed by Tom Armstrong

Gage calibrated 9/3/81

Pass x Fail ____

Operator B. Faris

Date 9/17-81

II-3.1 TENSILE LOAD

Cable 072081-4C-1

Sample Length ______ m

Gage Length 7.2 (3.6 x 2) m

			Specification
Starting Tensile Load(t=0)	820/2 = 410	lb_f	400 min
($1\ lb_f = 4.448$ N)	1823	N	1780 min

Adjustments During Test

Approximate Time s	Initial Load lb_f	Adjusted Load lb_f
15	380	410
50	380	405

Finished Tensile Load (t=60s) 402 lb_f

Post Test Continuity 1788 N

Number of Continuous Fibers	Specification
6	6

Remarks: ______

Observed by Mike Bowman

Gage Chatillon Model WT-10, serial 4389(ITT 7817908)

Pass x Fail ______

Operator R. Faris

Date 8-26-81

Cable #7

II-3.1 TENSILE LOAD

Cable 072081-4C-2

Sample Length ____________ m

Gage Length 7.36 (3.68 x 2) m

		Specification
Starting Tensile Load(t=0) 425	lb_f	400 min
(1 lb_f = 4.448 N) ____________	N	1780 min

Adjustments During Test

Approximate Time s	Initial Load lb_f	Adjusted Load lb_f
10	850	-

Finished Tensile Load (t=60s) 370 lb_f

Post Test Continuity ____________ N

Number of Continuous Fibers	Specification
6	6

Remarks: ____________

Pass x Fail ______

Operator Wheatley Khaunghlawn

Date 10-16-81

1.0 2.8 2.5

3.2 2.2

3.6

4.0 2.0

1.1

1.8

1.25 1.4 1.6

MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

APPENDIX G

TEMPERATURE CYCLING DATA

Table G-1. High and Low Temperature Test Results, Cable 1 and Cable 2.

	Fiber	CVD Number	Attenuation (dB/km) at 850 nm* Before Test	Attenuation After Test	Attenuation Δ	Dispersion (ns/km) at 900 nm Before Test	Dispersion After Test	Dispersion Δ	High Temp (Δ dB/km) +49°C	High Temp (Δ dB/km) +71°C	Low Temp (Δ dB/km) -55°C
	Cable 1: 071781-4C-1										
1	Blue	HG-090229	3.65	3.09	-0.56	0.36	0.37	+0.01	0.09	0.19	1.60
2	Orange	HG-090229	3.65	3.25	-0.40	0.36	0.51	+0.15	0.06	0.17	4.77
3	Brown	HG-090380	3.14	3.07	-0.07	0.93	1.09	+0.16	0.17	0.24	3.90
4	White	HG-090330	2.94	2.55	-0.39	0.52	1.52	+1.00	0.05	0.06	0.87
5	Slate	HG-090286	3.43	3.15	-0.28	0.76	1.35	+0.59	0.18	0.11	2.55
6	Green	HG-090289	3.42	3.30	-0.12	0.33	0.52	+0.19	0.21	0.28	1.68
	Average		3.36	3.07	-0.30	0.54	0.89	+0.35	0.13	0.18	2.56
	Cable 2: 071881-4C-1										
1	Blue	HG-090311	4.22	3.61	-0.61	0.94	1.08	+0.14	0.05	0.06	1.44
2	Orange	HG-090329	3.68	3.46	-0.22	0.77	0.80	+0.03	0.01	0.02	1.47
3	Brown	HG-090286	3.04	3.09	+0.05	0.72	0.78	+0.06	0.09	0.08	2.58
4	White	HG-090286	3.32	2.95	-0.37	0.84	1.01	+0.17	0.04	0.05	1.81
5	Slate	HG-090266	3.87	3.14	-0.73	1.39	1.20	-0.19	0.05	0.04	0.59
6	Green	HG-090359	2.84	3.29	+0.45	0.48	0.63	+0.15	0.01	0.00	2.03
	Average		3.49	3.26	-0.23	0.85	0.91	+0.06	0.04	0.04	1.65

*LED's for differential attenuation rated at 850 nm.

Table G-2. High and Low Temperature Test Results, Cable 3 and Cable 4.

	Fiber	CVD Number	Attenuation (dB/km) At 850 nm* Before Test	After Test	Δ	Dispersion (ns/km) at 900 nm Before Test	After Test	Δ	High Temp (Δ dB/km) +49°C	+71°C	Low Temp (Δ dB/km) -55°C
						Cable 3: 071881-4C-1					
1	Blue	HG-090192	3.29	3.23	-0.06	0.44	0.55	+0.11	0.04	0.02	10.12
2	Orange	HG-090240	3.15	3.40	+0.25	0.31	0.52	+0.21	0.11	0.14	5.72
3	Brown	HG-090918	3.34	3.15	-0.19	0.68	0.55	-0.13	0.04	0.09	2.72
4	White	HG-090228	3.20	3.56	+0.36	0.60	0.50	-0.10	0.00	0.01	2.03
5	Slate	HG-090236	3.23	4.11	+0.88	0.34	0.67	+0.33	0.10	0.16	1.50
6	Green	HG-090311	3.47	3.93	+0.46	1.03	1.20	+0.17	0.01	0.03	1.43
	Average		3.28	3.56	+0.28	0.56	0.66	+0.10	0.05	0.08	3.93
						Cable 4: 071881-4C-3					
1	Blue	HG-090272	3.52	3.65	+0.13	1.09	1.19	+0.10	0.02	0.07	2.85
2	Orange	HG-090258	3.74	3.72	-0.02	0.35	0.37	+0.02	0.01	0.07	2.95
3	Brown	HG-090273	3.13	3.25	+0.12	0.62	0.68	+0.06	0.01	0.05	2.52
4	White	HG-090267	3.40	3.18	-0.22	1.22	1.39	+0.17	0.09	0.14	5.54
5	Slate	HG-090289	3.44	3.34	-0.10	0.56	0.58	+0.02	0.07	0.01	3.10
6	Green	HG-090248	3.31	3.42	+0.11	0.56	0.51	-0.05	0.04	0.09	1.33
	Average		3.42	3.42	0.00	0.73	0.78	+0.05	0.04	0.07	3.04

*LED's for differential attenuation rated at 850 nm.

Table G-3. High and Low Temperature Test Results, Cable 5 and Cable 6.

	Fiber	CVD Number	Attenuation (dB/km) At 850 nm* Before Test	After Test	Δ	Dispersion (ns/km) At 900 nm Before Test	After Test	Δ	High Temp (Δ dB/km) +49°C	+71°C	Low Temp (Δ dB/km) -55°C
	Cable 5: 072081-4C-1										
1	Blue	HG-090238	4.53	4.27	-0.26	0.76	0.11	-0.65	0.02	0.02	2.08
2	Orange	HG-090285	3.50	3.50	0.00	1.37	1.21	-0.16	0.16	0.25	0.61
3	Brown	HG-090385	3.38	2.26	-1.12	1.46	1.52	+0.06	0.03	0.03	2.04
4	White	HG-090287	3.66	3.38	-0.28	0.98	0.92	-0.06	0.06	0.13	3.66
5	Slate	HG-090386	3.63	3.62	-0.01	1.61	1.24	-0.37	0.09	0.08	2.29
6	Green	HG-090357	3.43	3.39	-0.04	0.68	0.52	-0.16	0.04	0.03	1.46
	Average		3.69	3.40	-0.29	1.14	0.92	-0.22	0.06	0.09	2.02
	Cable 6: 071681-4C-1										
1	Blue	HG-090261	3.21	3.30	+0.09	0.32	0.76	+0.44	0.04	0.06	12.65
2	Orange	HG-090202	3.14	3.50	+0.36	0.72	0.73	+0.01	0.08	0.13	6.59
3	Brown	HG-090240	3.08	3.45	+0.37	0.51	0.52	+0.01	0.08	0.15	2.93
4	White	HG-090273	2.82	4.14	+1.32	0.21	0.66	+0.45	0.08	0.11	3.62
5	Slate	HG-090236	2.94	3.08	+0.14	0.69	0.71	+0.02	0.02	0.01	3.47
6	Green	HG-090189	4.07	3.90	-0.17	0.65	0.74	+0.09	0.24	0.24	6.40
	Average		3.21	3.56	+0.35	0.52	0.69	+0.17	0.09	0.12	5.94

*LED's for differential attenuation rated at 850 nm.

Table G-4. High and Low Temperature Test Results, Cable 7 and Cable 8.

	Fiber	CVD Number	Attenuation (dB/km) At 850 nm*			Dispersion (ns/km) At 900 nm			High Temp (Δ dB/km)		Low Temp (Δ dB/km)
			Before Test	After Test	Δ	Before Test	After Test	Δ	+49°C	+71°C	-55°C
			Cable 7: 072081-4C-1								
1	Blue	HG-090375	3.42	3.90	+0.48	1.00	0.97	+0.03	0.05	0.07	2.31
2	Orange	HG-090385	3.40	3.84	+0.44	1.22	1.26	+0.04	0.05	0.09	4.74
3	Brown	HG-090300	4.18	4.32	+0.14	0.37	0.44	+0.07	0.05	0.09	4.92
4	White	HG-090395	3.34	3.42	+0.08	0.87	1.22	+0.35	0.06	0.15	2.36
5	Slate	HG-090232	4.11	4.40	+0.29	0.69	1.02	+0.33	0.00	0.04	9.27
6	Green	HG-090197	3.73	4.32	+0.59	0.57	0.65	+0.08	0.03	0.04	2.70
	Average		3.69	4.03	+0.34	0.79	0.93	+0.15	0.04	0.08	4.38
			Cable 8: 082782-4C-1								
1	Blue	HG-090222	3.31	4.07	+0.76	1.45	1.80	+0.35	0.05	0.09	1.28
2	Orange	HG-100499B	2.95	2.81	-0.14	0.81	0.75	-0.06	0.60	0.74	4.77
3	Brown	HG-090352	3.29	3.06	-0.23	0.62	0.48	-0.14	0.14	0.19	2.04
4	White	HG-120079	3.62	3.46	-0.16	1.41	1.22	-0.19	0.07	0.12	3.48
5	Slate	HG-090394	3.94	3.32	-0.62	1.16	0.86	-0.30	0.22	0.43	1.38
6	Green	HG-090244	3.87	3.62	-0.25	0.66	0.74	+0.88	0.04	0.08	1.74
	Average		3.50	3.40	-0.10	1.01	0.97	-0.04	0.18	0.27	2.44

*LED's for differential attenuation rated at 850 nm.

Table G-5. High and Low Temperature Test Results, Cable 9 and Cable 10.

	Fiber	CVD Number	Attenuation (dB/km) At 850 nm* Before Test	After Test	Δ	Dispersion (ns/km) At 900 nm Before Test	After Test	Δ	High Temp (Δ dB/km) +49°C	+71°C	Low Temp (Δ dB/km) -55°C
	Cable 9: 102781-4C-1										
1	Blue	HG-120188	2.95	3.69	+0.74	0.40	0.50	+0.10	0.17	0.16	1.52
2	Orange	HG-090618	4.29	3.28	-1.01	0.52	0.63	+0.11	0.13	0.21	0.78
3	Brown	HG-090681	3.34	3.52	+0.18	0.72	0.76	+0.04	0.17	0.22	4.92
4	White	HG-100615	3.38	3.43	+0.05	1.17	1.57	+0.40	0.17	0.23	1.62
5	Slate	HG-090618	3.80	4.37	+0.57	0.39	0.46	+0.07	0.14	0.18	1.20
6	Green	HG-090223	3.98	4.26	+0.28	0.88	0.54	-0.34	0.41	0.41	2.79
	Average		3.62	3.76	+0.14	0.68	0.74	+0.06	0.19	0.23	2.13
	Cable 10: 091881-4C-2										
1	Blue	HG-090354	3.64	3.73	+0.09	1.05	0.95	-0.10	0.33	0.39	1.59
2	Orange	HG-090314	3.34	3.58	+0.24	1.00	1.71	+0.71	0.49	0.44	2.26
3	Brown	HG-100528	4.30	4.26	-0.04	0.43	1.16	+0.73	0.37	0.42	2.48
4	White	HG-100528	2.96	3.82	+0.86	1.04	1.08	+0.04	2.03	2.08	4.20
5	Slate	HG-100528	4.01	3.77	-0.24	0.52	0.58	+0.06	-0.11	-0.06	1.76
6	Green	HG-090456	3.67	3.50	-0.17	1.49	1.49	0.00	0.12	0.21	1.62
	Average		3.65	3.77	+0.12	0.92	1.16	+0.24	0.53	0.58	2.31

*LED's for differential attenuation rated at 850 nm.

Table G-6. High and Low Temperature Test Results, Cable 11 and Cable 12.

	Fiber	CVD Number	Attenuation (dB/km) At 850 nm*			Dispersion (ns/km) At 900 nm			High Temp (Δ dB/km)		Low Temp (Δ dB/km)
			Before Test	After Test	Δ	Before Test	After Test	Δ	+49°C	+71°C	-55°C
			Cable 11: 112381-4C-1								
1	Blue	HG-100638	3.80	3.40	-0.40	0.92	1.05	+0.13	0.10	0.13	4.81
2	Orange	HG-120280	3.43	3.72	+0.29	0.61	0.50	-0.11	0.33	0.05	21.05
3	Brown	HG-120280	3.62	4.04	+0.42	0.63	0.52	-0.11	0.34	0.11	20.71
4	White	HG-100638	3.19	4.10	+0.91	1.20	1.08	-0.12	0.03	0.06	6.64
5	Slate	HG-120280	3.83	3.43	-0.40	0.73	0.62	-0.11	0.23	0.19	8.51
6	Green	HG-120274	3.23	2.91	-0.32	1.18	0.92	-0.26	0.10	0.12	12.57
	Average		3.52	3.60	-0.08	0.88	0.78	-0.10	0.18	0.11	12.38
			Cable 12: 091781-4C-1								
1	Blue	HG-090594	4.19	4.15	-0.04	0.70	0.39	-0.31	0.06	0.19	11.22
2	Orange	HG-120132	3.03	2.78	-0.26	1.20	0.78	-0.42	0.01	0.05	0.43
3	Brown	HG-100524	3.00	3.04	+0.04	0.72	0.31	-0.41	0.16	0.33	21.46
4	White	HG-090328	3.37	3.40	+0.03	0.70	0.78	+0.08	0.02	0.16	4.03
5	Slate	HG-100524	3.70	2.92	-0.78	1.18	1.04	-0.14	0.03	0.20	2.37
6	Green	HG-120150	3.03	3.28	+0.25	0.71	0.52	-0.19	-0.06	0.04	3.84
	Average		3.38	3.26	-0.12	0.86	0.63	-0.23	0.04	0.16	7.22

*LED's for differential attenuation rated at 850 nm.

Table G-7. Attenuation Versus Wavelength* (dB/km) After Temperature Cycling.

Cable 1: 071781-4C-1

	Fiber	CVD Number	Wavelength (nm) 820	850	1060	1100	1200	1300
1	Blue	HG-090229	3.55	3.14	1.47	1.35	1.13	1.19
2	Orange	HG-090229	3.36	2.94	1.36	1.22	0.98	1.05
3	Brown	HG-090380	3.80	3.36	1.74	1.56	1.33	1.42
4	White	HG-090330	3.89	3.38	3.06	1.43	1.21	1.28
5	Slate	HG-090286	3.29	2.92	1.44	1.30	1.28	1.22
6	Green	HG-090289	3.80	3.36	1.67	1.56	1.28	1.36

Cable 2: 071881-4C-1

	Fiber	CVD Number	820	850	1060	1100	1200	1300
1	Blue	HG-090311	4.21	3.63	1.60	1.43	1.24	1.04
2	Orange	HG-090329	3.90	3.46	1.60	1.48	1.23	1.36
3	Brown	HG-090286	3.57	3.09	1.51	1.34	1.22	1.11
4	White	HG-090286	3.40	2.95	1.33	1.21	1.05	1.04
5	Slate	HG-090266	3.49	3.14	1.37	1.21	0.96	1.11
6	Green	HG-090359	3.75	3.29	1.49	4.13	1.57	1.08

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*Injected NA 0.089.

Table G-7. Attenuation Versus Wavelength* (dB/km) After Temperature Cycling (continued).

Cable 3: 071881-4C-2

	Fiber	CVD Number	Wavelength (nm) 820	850	1060	1100	1200	1300
1	Blue	HG-090192	3.68	3.23	1.60	1.46	1.22	1.17
2	Orange	HG-090240	3.79	3.29	1.61	1.43	1.43	3.35
3	Brown	HG-090418	3.78	3.26	1.56	1.41	1.19	1.22
4	White	HG-090228	3.90	3.30	1.53	1.35	1.03	0.94
5	Slate	HG-090236	3.63	3.12	1.46	1.34	1.08	1.13
6	Green	HG-090311	3.85	3.32	1.25	1.08	0.71	0.58

Cable 4: 071881-4C-3

	Fiber	CVD Number	820	850	1060	1100	1200	1300
1	Blue	HG-090272	4.22	3.63	1.74	1.61	1.30	1.30
2	Orange	HG-090258	4.21	3.73	1.93	1.76	1.47	1.55
3	Brown	HG-090273	3.69	3.24	1.50	1.29	1.01	0.99
4	White	HG-090267	3.86	3.36	1.50	1.37	1.16	1.26
5	Slate	HG-090289	3.92	3.42	1.76	1.64	1.42	1.41
6	Green	HG-090248	3.91	3.45	1.77	1.62	1.35	1.32

Injected NA 0.089.

Table G-7. Attenuation Versus Wavelength* (dB/km) After Temperature Cycling (continued).

Cable 5: 072081-4C-1

	Fiber	CVD Number	820	850	1060	1100	1200	1300
			Wavelength (nm)					
1	Blue	HG-090238	4.64	4.27	2.54	2.38	2.05	2.08
2	Orange	HG-090285	4.02	3.50	1.70	1.53	1.93	1.18
3	Brown	HG-090385	3.24	2.26	1.48	1.54	1.30	1.22
4	White	HG-090287	3.86	3.38	1.64	1.51	1.23	1.19
5	Slate	HG-090386	4.05	3.62	1.66	1.53	1.25	1.21
6	Green	HG-090357	3.85	3.39	1.70	1.56	1.36	1.28

Cable 6: 071681-4C-1

	Fiber	CVD Number	820	850	1060	1100	1200	1300
1	Blue	HG-090261	3.90	3.30	1.55	1.39	1.16	1.19
2	Orange	HG-090202	3.78	3.50	1.71	1.57	1.79	1.22
3	Brown	HG-090240	3.95	3.45	1.85	1.60	1.65	3.50
4	White	HG-090273	4.59	4.14	2.38	2.21	2.09	2.04
5	Slate	HG-090236	3.59	3.08	1.37	1.25	1.03	1.03
6	Green	HG-090189	4.61	3.90	1.77	1.66	1.35	1.22

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*Injected NA 0.089.

Table G-7. Attenuation Versus Wavelength* (dB/km) After Temperature Cycling (continued).

Cable 7: 072081-4C-2

	Fiber	CVD Number	820	850	1060	1100	1200	1300
			Wavelength (nm)					
1	Blue	HG-090375	3.95	3.37	1.49	1.31	1.06	0.99
2	Orange	HG-090385	4.07	3.56	1.67	1.57	1.27	0.80
3	Brown	HG-090300	4.71	4.28	2.31	2.16	1.83	1.86
4	White	HG-090395	3.85	3.32	1.43	1.35	1.14	1.49
5	Slate	HG-090232	4.71	4.13	2.06	1.89	1.54	1.52
6	Green	HG-090197	4.14	3.66	1.95	1.81	1.56	1.38

Cable 8: 082781-4C-1

	Fiber	CVD Number	820	850	1060	1100	1200	1300
1	Blue	HG-090222	4.66	4.07	2.54	2.24	2.29	3.96
2	Orange	HG-100499B	3.35	2.81	1.38	1.22	0.96	1.00
3	Brown	HG-090352	3.77	3.06	1.51	1.32	1.01	1.11
4	White	HG-120079	3.71	3.46	1.52	1.46	1.18	1.13
5	Slate	HG-090394	4.01	3.32	1.42	1.31	1.01	1.14
6	Green	HG-090244	4.06	3.62	1.75	1.70	1.46	1.40

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*Injected NA 0.089.

Table G-7. Attenuation Versus Wavelength* (dB/km) After Temperature Cycling (continued).

Cable 9: 102781-4C-1

	Fiber	CVD Number	Wavelength (nm) 820	850	1060	1100	1200	1300
1	Blue	HG-120188	4.20	3.69	1.85	1.72	1.44	1.49
2	Orange	HG-090618	3.75	3.28	1.71	1.53	1.29	1.23
3	Brown	HG-090681	4.02	3.52	1.76	1.62	1.33	1.35
4	White	HG-100615	3.85	3.43	1.89	1.75	1.62	1.80
5	Slate	HG-090618	4.87	4.37	2.63	2.44	2.31	2.15
6	Green	HG-090223	4.83	4.26	2.53	2.33	2.08	2.15

Cable 10: 091881-4C-2

	Fiber	CVD Number	820	850	1060	1100	1200	1300
1	Blue	HG-090354	4.45	3.73	1.79	1.58	1.30	1.32
2	Orange	HG-090314	4.00	3.58	1.84	1.85	1.59	1.63
3	Brown	HG-100528	4.73	4.26	2.47	2.32	2.04	1.99
4	White	HG-100528	4.34	3.82	1.88	1.40	1.09	1.10
5	Slate	HG-100528	4.03	3.77	2.04	1.95	1.66	1.66
6	Green	HG-090456	4.02	3.50	1.61	1.47	1.31	1.45

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*Injected NA 0.089.

Table G-7. Attenuation Versus Wavelength* (dB/km) After Temperature Cycling (continued).

Cable 11: 112381-4C-1

	Fiber	CVD Number	Wavelength (nm) 820	850	1060	1100	1200	1300
1	Blue	HG-100638	3.81	3.40	1.58	1.56	1.29	1.28
2	Orange	HG-120280	4.12	3.72	1.91	1.94	1.88	1.80
3	Brown	HG-120280	4.29	4.04	2.35	2.26	1.99	1.92
4	White	HG-100638	4.52	4.10	2.32	2.29	2.07	2.10
5	Slate	HG-120280	3.87	3.43	1.68	1.66	1.39	1.36
6	Green	HG-120274	3.40	2.91	0.91	0.83	0.53	0.41

Cable 12: 091781-4C-1A

	Fiber	CVD Number	820	850	1060	1100	1200	1300
1	Blue	HG-090594	4.59	4.15	2.26	1.83	1.75	1.79
2	Orange	HG-120132	3.18	2.78	1.28	1.19	1.00	0.93
3	Brown	HG-100524	3.50	3.04	1.51	1.42	1.20	0.65
4	White	HG-090328	3.91	3.40	1.70	1.55	1.32	1.23
5	Slate	HG-100524	3.39	2.92	1.38	1.25	1.11	1.10
6	Green	HG-120150	3.74	3.28	1.73	1.56	1.13	1.15

Injected NA 0.089

Table G-8. Attenuation Versus Injected NA After Temperature Cycling (Wavelength 820 nm).

Cable 1: 071781-4C-1

	Fiber	CVD Number	Injection NA 0.089	0.124	0.176	0.243
1	Blue	HG-090229	3.55	3.34	3.09	2.80
2	Orange	HG-090229	3.36	3.13	2.58	2.48
3	Brown	HG-090380	3.80	3.89	4.04	4.19
4	White	HG-090330	3.89	3.93	3.95	4.08
5	Slate	HG-090286	3.29	3.93	4.26	3.33
6	Green	HG-090289	3.80	3.69	3.99	3.96

Cable 2: 071881-4C-1

	Fiber	CVD Number	Injection NA 0.089	0.124	0.176	0.243
1	Blue	HG-090311	4.21	4.33	4.48	4.44
2	Orange	HG-090329	3.90	3.89	4.05	4.25
3	Brown	HG-090286	3.57	3.70	4.61	3.68
4	White	HG-090286	3.40	3.47	3.60	3.74
5	Slate	HG-090266	3.49	3.50	3.63	3.78
6	Green	HG-090359	3.75	3.75	3.94	4.18

Table G-8. Attenuation Versus Injected NA After Temperature Cycling (Wavelength 820 nm) (continued).

Cable 3: 071881-4C-2

Fiber		CVD Number	Injection NA 0.089	0.124	0.176	0.243
1	Blue	HG-090192	3.68	3.71	3.47	3.18
2	Orange	HG-090240	3.79	4.01	3.81	3.94
3	Brown	HG-090418	3.78	4.06	4.26	4.35
4	White	HG-090228	3.90	4.20	4.23	4.21
5	Slate	HG-090236	3.63	3.51	3.65	3.80
6	Green	HG-090311	3.85	4.01	4.11	4.37

Cable 4: 071881-4C-3

Fiber		CVD Number	0.089	0.124	0.176	0.243
1	Blue	HG-090272	4.09	3.96	4.54	4.22
2	Orange	HG-090258	4.21	4.30	4.37	4.22
3	Brown	HG-090273	3.69	3.79	3.76	4.02
4	White	HG-090267	3.86	3.86	3.85	3.91
5	Slate	HG-090289	3.92	3.97	4.05	4.24
6	Green	HG-090248	3.91	4.12	4.15	4.21

Table G-8. Attenuation Versus Injected NA After Temperature Cycling (Wavelength 820 nm) (continued).

Cable 5: 072081-4C-1

	Fiber	CVD Number	Injection NA 0.089	0.124	0.176	0.243
1	Blue	HG-090238	4.64	4.49	4.48	4.33
2	Orange	HG-090285	4.02	4.08	4.21	4.23
3	Brown	HG-090385	3.24	6.94	3.40	3.53
4	White	HG-090287	3.86	3.76	3.92	4.08
5	Slate	HG-090386	4.05	4.02	4.11	4.06
6	Green	HG-090357	3.85	3.84	4.08	4.17

Cable 6: 071681-4C-1

	Fiber	CVD Number	Injection NA 0.089	0.124	0.176	0.243
1	Blue	HG-090261	3.90	4.03	4.03	4.11
2	Orange	HG-090202	3.78	3.93	4.16	4.42
3	Brown	HG-090240	3.95	3.98	4.10	4.36
4	White	HG-090273	4.59	4.50	4.17	4.20
5	Slate	HG-090236	3.59	3.53	3.63	3.90
6	Green	HG-090189	4.61	4.55	4.61	4.72

Table G-8. Attenuation Versus Injected NA After Temperature Cycling (Wavelength 820 nm) (continued).

Cable 7: 072081-4C-2

	Fiber	CVD Number	Injection NA 0.089	0.124	0.176	0.243
1	Blue	HG-090375	3.95	4.08	4.01	4.38
2	Orange	HG-090385	4.07	4.10	4.35	4.49
3	Brown	HG-090300	4.71	4.78	4.80	4.87
4	White	HG-090395	3.85	3.87	4.05	4.19
5	Slate	HG-090232	4.71	4.76	4.85	4.89
6	Green	HG-090197	4.14	4.19	4.26	4.63

Cable 8: 082781-4C-1

	Fiber	CVD Number	0.089	0.124	0.176	0.243
1	Blue	HG-090222	4.66	4.57	4.77	4.62
2	Orange	HG-100499B	3.35	3.71	3.65	3.85
3	Brown	HG-090352	3.77	4.05	4.27	3.91
4	White	HG-120079	3.71	3.80	4.18	4.16
5	Slate	HG-090394	4.01	3.79	4.22	4.08
6	Green	HG-090244	4.06	4.64	4.34	4.25

Table G-8. Attenuation Versus Injected NA After Temperature Cycling (Wavelength 820 nm) (continued).

Cable 9: 102781-4C-1

	Fiber	CVD Number	Injection NA 0.089	0.124	0.176	0.243
1	Blue	HG-120188	4.20	4.03	4.14	4.22
2	Orange	HG-090618	3.75	3.58	3.53	3.57
3	Brown	HG-090681	4.02	4.10	4.16	4.47
4	White	HG-100615	3.85	4.37	4.25	4.08
5	Slate	HG-090618	4.87	4.98	4.71	5.04
6	Green	HG-090223	4.83	4.70	4.69	4.88

Cable 10: 091881-4C-2

	Fiber	CVD Number	Injection NA 0.089	0.124	0.176	0.243
1	Blue	HG-090354	4.45	4.34	4.44	4.53
2	Orange	HG-090314	4.00	3.88	4.33	3.93
3	Brown	HG-100528	4.73	4.84	5.14	5.25
4	White	HG-100528	4.34	4.80	4.67	4.80
5	Slate	HG-100528	4.03	3.79	4.49	4.54
6	Green	HG-090456	4.02	4.22	4.14	4.09

Table G-8. Attenuation Versus Injected NA After Temperature Cycling (Wavelength 820 nm) (continued).

Cable 11: 112381-4C-1

	Fiber	CVD Number	Injection NA 0.089	0.124	0.176	0.243
1	Blue	HG-100638	3.81	3.84	4.27	4.32
2	Orange	HG-120280	4.12	4.21	4.25	4.38
3	Brown	HG-120280	4.29	4.35	3.72	4.12
4	White	HG-100638	4.52	4.46	4.97	4.96
5	Slate	HG-120280	3.87	3.77	4.11	4.00
6	Green	HG-120274	3.40	3.30	3.60	3.63

Cable 12: 091781-4C-1A

	Fiber	CVD Number	0.089	0.124	0.176	0.243
1	Blue	HG-090594	4.59	4.65	4.62	4.71
2	Orange	HG-120132	3.18	3.15	3.57	3.73
3	Brown	HG-100524	3.50	3.77	3.98	4.14
4	White	HG-090328	3.91	3.94	3.77	4.11
5	Slate	HG-100524	3.39	3.54	3.54	3.83
6	Green	HG 120150	3.74	3.55	3.80	3.85

Table G-9. Numerical Aperture (90% Power) After Temperature Cycling (Wavelength 820 nm).

	Fiber	Cable Number 1		2		3		4		5		6	
1	Blue	HG-090229	0.19	HG-090311	0.22	HG-090192	0.18	HG-090272	0.22	HG-090238	0.20	HG-090261	0.21
2	Orange	HG-090229	0.19	HG-090329	0.21	HG-090240	0.19	HG-090258	0.20	HG-090285	0.19	HG-090202	0.23
3	Brown	HG-090380	0.18	HG-090286	0.22	HG-090418	0.21	HG-090273	0.21	HG-090385	0.23	HG-090240	0.20
4	White	HG-090330	0.21	HG-090286	0.25	HG-090228	0.19	HG-090267	0.21	HG-090287	0.19	HG-090273	0.22
5	Slate	HG-090286	0.20	HG-090266	0.27	HG-090236	0.20	HG-090289	0.23	HG-090386	0.20	HG-090236	0.21
5	Green	HG-090289	0.19	HG-090359	0.23	HG-090311	0.19	HG-090248	0.21	HG-090357	0.19	HG-090357	0.21

	Fiber	7		8		9		10		11		12	
1	Blue	HG-090375	0.23	HG-090222	0.20	HG-120188	0.19	HG-090354	0.19	HG-100638	0.19	HG-090594	0.20
2	Orange	HG-090385	0.20	HG-100499B	0.21	HG-090618	0.17	HG-090314	0.20	HG-120280	0.20	HG-120132	0.19
3	Brown	HG-090300	0.23	HG-090352	0.20	HG-090681	0.17	HG-100528	0.18	HG-120280	0.18	HG-100529	0.18
4	White	HG-090395	0.22	HG-120079	0.22	HG-100615	0.18	HG-100528	0.21	HG-100638	0.19	HG-090328	0.19
5	Slate	HG-090232	0.23	HG-090394	0.20	HG-090618	0.18	HG-100528	0.18	HG-120280	0.18	HG-100524	0.20
5	Green	HG-090197	0.21	HG-090294	0.22	HG-090223	0.18	HG-090456	0.20	HG-120274	0.28	HG-120150	0.19

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